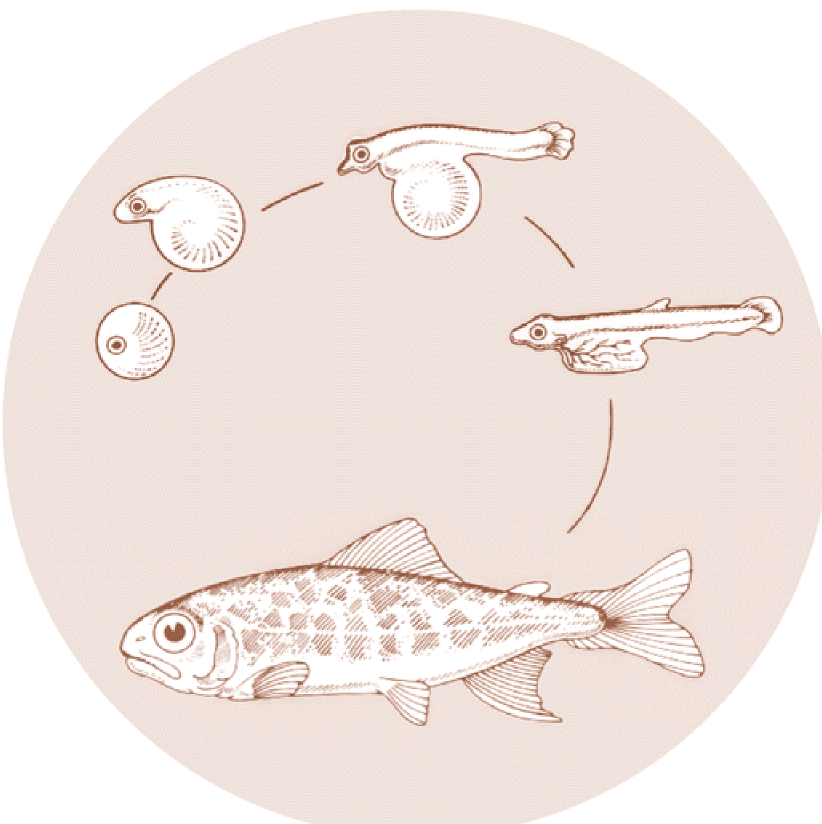
UMATILLA HATCHERY MONITORING AND EVALUATION

November 1, 1994 - October 31, 1995

Annual Report 1995



DOE/BP-23720-4

This report was funded by the Bonneville Power Administration (BPA), U.S. Department of Energy, as part of BPA's program to protect, mitigate, and enhance fish and wildlife affected by the development and operation of hydroelectric facilities on the Columbia River and its tributaries. The views of this report are the author's and do not necessarily represent the views of BPA.

This document should be cited as follows:

Umatilla Hatchery Monitoring and Evaluation - Hayes, Michael C., R. W. Carmichael, S. M. Focher, R. Wes Stonecypher, Jr.; Fish Health Monitoring and Evaluation - Groberg, Warren J. Jr., S. T. Onjukka, K. Waln, Oregon Dept. of Fish and Wildlife, Umatilla Hatchery Monitoring and Evaluation, Annual Report 1995 to Bonneville Power Administration, Portland, OR, Contract 91-BI-23720, Project 90-005, 148 electronic pages (BPA Report DOE/BP-23720-4)

Bonneville Power Administration
Environment, Fish and Wildlife Division
P.O. Box 3621
905 N.E. 11th Avenue
Portland, OR 97208-3621

UMATILLA HATCHERY MONITORING AND EVALUATION

ANNUAL REPORT 1995
(NOVEMBER 1,1994 - OCTOBER 31,1995)

Umatilla Hatchery Monitoring and Evaluation
Prepared by:

Michael Hayes
Richard W. Carmichael
Shannon M. Focher
R. Wes Stonecypher, Jr.

Fish Health Monitoring and Evaluation
Prepared by:

Warren J. Groberg, Jr.
Sam T. Onjukka
Karen Waln

Oregon Department of Fish and Wildlife
Portland, OR

Prepared for:

U.S. Department of Energy
Bonneville Power Administration
Environment, Fish and Wildlife
P. 0. Box 3621
Portland, OR 97208-362 1

Project Number 90-005
Contract Number DE-BI79-9 lBP23720

CONTENTS

Page

LIST OF TABLES

Page

Page

LIST OF FIGURES

Page

Page

RESULTS

LIST OF TABLES

LIST OF FIGURES

Page

LIST OF APPENDIX TABLES

Page

Page

EXECUTIVE SUMMARY

This report covers the first four years of comprehensive monitoring and evaluation of Umatilla Hatchery. Fish from Umatilla Hatchery were first released in the Umatilla River in 1992. Rearing experiments of subyearling fall chinook salmon at the initial production densities have been completed. Rearing of other groups is continuing or has been temporarily discontinued because of egg shortages or limited water availability. A unique feature of the Umatilla Hatchery evaluation is a comprehensive fish health monitoring regimen. Although some adult return data has been recovered, the majority of the data on post-release survival is incomplete. Conclusions drawn in this report should be viewed as preliminary and be used in conjunction with additional information as it becomes available.

Objectives for FY 1995

Hatchery Monitoring and Evaluation

1. Document egg-take, and egg-to-fry and egg-to-smolt survival for salmon and steelbead reared at Umatilla Hatchery

2. Document rearing densities and loading factors for salmon and steelbead reared at Umatilla and Bonneville hatcheries and released in the Umatilla River.

3. Document number, size, time, and release location for salmon and steelhead reared at Umatilla and Bonneville hatcheries and released in the Umatilla River.

4. Monitor water quality parameters in Michigan and Oregon index raceways containing salmon and steelhead.

5. Collect and compare monthly length, weight, and condition factor estimates for salmon and steelhead reared in Michigan or Oregon raceways at Umatilla Hatchery.

6. Calculate growth rates for salmon and steelhead reared in Michigan or Oregon raceways at Umatilla Hatchery.

7. Determine fm condition, degree of descaling, degree of smolting, length, weight, and condition factor at release for salmon and steelbead reared at Umatilla and Bonneville Hatcheries and released into the Umatilla River.

8. Compare the physiological stress response of chinook salmon reared in Michigan and Oregon raceways at Umatilla Hatchery.

9. Compare the $Na^{+}K^{+}$ ATPase activity of gill tissue in spring chinook salmon reared at Umatilla Hatchery.

10. Freeze brand and release representative groups of fish reared at Umatilla and Bonneville Hatcheries to evaluate smolt migration performance.

11. Summarize information from branded salmon and steelhead released in the Umatilla River and recovered at the John Day Dam.

12. Fin mark, coded-wire-tag or blank-wire-tag, determine tag retention and fin clip quality, and release replicate groups of salmon and steelhead to evaluate smolt-to-adult survival.

13. Summarize catch and escapement information from coded and blank-wire-tagged salmon and steelbead released in the Umatilla River.

14. Evaluate adult straying of fall chinook salmon from releases in the Umatilla River.

15. Develop and implement statistical creel methods to estimate the sport harvest of salmon and steelbead.

16. Participate in the development of a water quality sampling and monitoring in the Umatilla River Basin.

17. Participate in planning the production and management activities of anadromous fish in the Umatilla River Basin.

Fish Health Monitoring and Evaluation

1. Conduct monthly fish health examinations on fresh dead or moribund, and healthy juvenile fish from index raceways of each species and stock of fish reared at Umatilla Hatchery.

2. Conduct fish health examinations on 30 juvenile fish per index raceway of each species and stock reared at Umatilla Hatchery.

3. Conduct preliberation fish health examinations on 30 juvenile fish per evaluation raceway of 1995 yearling fall chinook salmon at Bonneville Hatchery.

4. Collect gills at preliberation from 10 juvenile fish from a cross-section of upper, middle and lower Michigan raceways, and upper and lower Oregon raceways, for histological examination.

5. Using data obtained from monthly and preliberation fish health examinations, assess what effects differing rearing strategies and environments have on fish health.

6. Examine fish when unusual loss or behavior occurs by appropriate diagnostic methods. Implement therapeutic or prophylactic measures to control, moderate or prevent disease outbreaks.

7. Continue implementation of Federal Drug Administration Investigation New Animal Drug protocols or erytbromycin feeding of juvenile, spring chinook salmon at Umatilla Hatchery.

8. Continue implementation of Federal Drug Administration Investigation New Animal Drug protocols for oxytetracycline, formalin, and chloramine-T as needed for disease treatment at Umatilla Hatchery.

9. Examine fish at acclimation facilities which are part of the Umatilla program for loss problems or preliberation following extended acclimation.

10. Continue to develop expertise in statistical analyses pertinent to the epidemiological evaluations at Umatilla Hatchery. Use this to analyze trends in all data accumulated to date.

11. Investigate the use of polymerase chain reaction methodology for confirmatory diagnosis and identification of *Flexibacter psychrophilus*.

12. Conduct ***in vitro*** experiments to determine the survival of ***R. salmoninalrum*** in water from Umatilla Hatchery.

Accomplishments and Findings for FY 1995

Hatchery Monitoring and Evaluation

We achieved all of our objectives in FY 1995. **Nearly 4** million chinook salmon and steelhead were released in the Umatilla River as planned from November 1994 to June 1995. Production of all groups exceeded or were within 10% of the FY 1995 goal. Most groups were released at sixes close to the program goals. Spring chinook salmon released in the fall were approximately 25% larger than planned. The spring chinook salmon produced at Bonneville Hatchery intended for fall release were held and released as yearlings.

Chinook salmon and steelhead were successfully marked. More than 2.4 million fall chinook salmon were wire-tagged in 1994-95 and tag retention was greater than 95 % . Only 2.0% of the ventral fin clips used to identify subyearling fall chinook salmon were poorly clipped or unclipped.

Few branded steelbead were recovered at the John Day Dam in 1995. However, the effect of Columbia River flow on brand collection and smolt survival indices is unknown.

Although smolt-to-adult survival data is incomplete, it appears that subyearling fall chinook salmon can be successfully reared and released from Michigan raceways. Stress response and migration performance differed minimally between fish reared in different systems or in different passes within a system. Some Michigan reared groups suffered more descaling and converted food less efficiently.

Acclimation and increased Columbia River flow may improve the migration performance and survival of subyearling fall chinook salmon. Acclimated subyearlings released in 1995 were larger and had lower condition factors than previously released non-acclimated groups. Although direct comparisons are not valid, downstream migration rates and survival to the John Day were significantly improved in 1995.

Adult fall chinook salmon straying continued for fish released prior to the construction of Umatilla Hatchery. Most of the hatchery fish escaping above Lower Granite Dam on the Snake River in 1994 originated from Umatilla River releases. Completed and in-progress corrective measures should reduce straying.

We collected fin clip and blank-wire tag data from fall chinook salmon returning to the Umatilla River in 1994. Detection of body tags with wand and field detectors was inadequate. New detection methods are being investigated.

Poor adult survival was indicated for most broods released in 1992, a below normal water year in the Umatilla basin. Few 2-year old fall chinook jacks returned from subyearling releases and steelhead returns have been minimal. Some fall chinook salmon released as yearlings returned as age 2 subjacks. Initial adult returns from groups released in 1993 were more encouraging. Recovery rates of one-salt steelbead in 1994-95 were equal to or greater than total survival rates for the 1991 brood. Recovery rates for steelhead released in April were greater than for groups released in May. The run timing of adult hatchery steelhead was similar to wild fish.

Smolt development for spring chinook salmon cannot be predicted by changes in ATPase. Salmon released in the fall showed declining levels prior to release, yet many fish immediately migrated out of the system. Salmon released in spring showed no significant changes in ATPase during rearing yet rapidly migrated out of the system.

Ten percent of the fall chinook salmon jacks and 3 % of the coho salmon estimated to enter the Umatilla River were harvested between Three Mile Falls Dam and the mouth of the Umatilla River in 1994. Angling pressure during the 1994 fall chinook-coho salmon season was similar to previous years, but pressure during the 1994-1995 steelhead season was 40% lower. Steelbead catch rates in 1994-95 improved nearly 100% compared to 1993-94.

Fish Health Monitoring and Evaluation

Adult fall chinook salmon fish health monitoring was conducted at Priest Rapids and adult spring chinook salmon fish health monitoring was conducted at Lyons Ferry. Both stocks were negative for culturable viruses. The fall chinook salmon were negative or had low levels of *Renibacterium salmoninarum* antigen as measured by the enzyme-linked immunosorbent assay. One spring chinook female had clinical levels of antigen and the remaining fish tested in the negative/very low postive range.

Bacterial kidney disease was again a significant infectious disease in juvenile spring chinook salmon reared at Umatilla Hatchery. Erythromycin therapy was needed to control an outbreak in the fall of 1994. Erythromycin toxicity continues to be observed following dietary treatments of the antibiotic.

There has been no convincing evidence for horizontal transmission of *R. salmoninarum*, the causative agent of bacterial kidney disease, between first pass and reuse water raceways at Umatilla Hatchery. One exception to this was statistically higher enzyme-linked immunosorbent assay readings for juvenile spring chinook salmon in a reuse water Michigan raceway over those in its companion first pass raceway.

There are indications based on mortality profiles that spring chinook salmon juveniles in reuse water raceways have an earlier onset of bacterial kidney disease than fish in first pass raceways when outbreaks occur. Also, during non-outbreak periods a greater proportion of the mortality in reuse raceways have clinical bacterial kidney disease,& those in first pass raceways. Together, this suggests mere are factors operating in reuse raceways that exacerbate *R. salmoninarum* infection.

Significant morbidity and mortality of undetermined causes were documented in yearling steelbead and spring chinook salmon during February of 1995. This occurred soon after a minor drawdown of the John Day Reservoir pool and a possible relationship is suspected but unproven.

Flexibacter psychrophilus, the agent of bacterial cold water disease, was occasionally isolated from both chinook salmon stocks. There were no outbreaks of the disease, or even known losses to it.

High prevalences of infectious hematopoietic necrosis virus were detected in the Umatilla River adult steelhead spawned at Minthom Pond in 1995. This was also the first time the virus was detected in adult steelhead at Minthom in eight consecutive years of sampling every spawned adult.

Presentations on fish health investigations at Umatilla Hatchery were given at the Northwest Fish Culture Conference in December of 1995 and at the Western Fish Disease Conference in June of 1995.

Management Implications and Recommendations

Hatchery Monitoring and Evaluation

1. Oxygen supplementation may be used to increase the production of subyearling fall chinook salmon, yearling spring chinook salmon and steelhead. Water quality and fish quality were similar for high density Michigan raceways compared to Oregon raceways. Rearing in Michigan raceways should be continued.

2. Subyearling fall chinook salmon were successfully reared in Michigan raceways. Although smolt-to-adult survival data is incomplete, we recommend increasing rearing densities in Michigan raceways to determine system capabilities.

3. The use of ATPase as an indicator of smolt development in spring chinook salmon should be discontinued. Measurements show that smolts reared in Michigan and Oregon raceways develop at similar rates; however, values do not provide additional information on the optimum release time.

4. Steelbead escaping from the Bonifer Springs acclimation pond may limit our ability to successfully monitor release strategies. Brand data suggests that steelbead may be escaping prior to the intended release date. We recommend that the water control structure be improved at Bonifer Springs.

5. Adult return goals for steelhead will not be achieved if graded small steelhead released in May continue to perform poorly. Adult returns will enable us to determine if poor performance is a recurring pattern. Rearing Wallowa stock steelhead at Umatilla Hatchery as described in the master plan (CTUIR and ODFW 1990) should be investigated. This would allow us to simultaneously test the Michigan and Oregon systems.

6. Similar run timing of returning adult steelbead indicates partial success in producing a hatchery product that emulates the wild population. Other hatchery steelhead performance indicators, including spawning success, should be determined to fully evaluate supplementation.

7. Fall chinook salmon straying into the Snake River may cause reductions in the subyearling program and wire tagging all fish should continue. Most strays originated from subyearling releases prior to Umatilla Hatchery construction. Although blank-wire tagging all groups will

limit future escapement of strays past Lower Granite Dam, the escapement of Snake River natural fish will determine if the proportion of Umatilla strays exceeds the stray criteria of 5 %.

8. Residualism by fall chinook salmon may reduce smolt-to-adult survival. Many fish released from Bonneville Hatchery as yearlings return to Three-Mile Falls Dam as age 2 subjacks. We will assess the interaction between size-at-release goals and residualism.

9. Preliminary smolt-to-adult data indicates that 1992 was a poor release year. Adult returns for fall chinook salmon and steelhead released in that year have been minimal and may provide limited information on Michigan and Oregon rearing methods.

Fish Health Monitoring and Evaluation

1. Without monitoring of adult returns for ***R. salmoninarum*** it would be premature to draw conclusions and make recommendations relative to rearing strategies and their affect on bacterial kidney disease severity in spring chinook salmon at Umatilla Hatchery. Outbreaks have been relatively mild and controlled by erythromycin therapy. There have been some indications, however, that Michigan raceways and reuse water raceways are more affected. A plan to monitor adult returns for ***R. salmoninarum*** should be developed to complete these epidemiological investigations.

2. Empirical evidence, other studies, and some data from the Umatilla project indicate that the severity **of the** disease in juveniles is directly correlated to the severity of infection in the female brood stock. A program of rearing progeny segregated by levels of infection of adult females should be considered, although limitations of water may preclude this. This may be prudent because under conditions of severe outbreaks, erythromycin therapy may not be effective in controlling bacterial kidney disease in Michigan or reuse water raceways.

3. A plan should be developed to implement water chemistry monitoring if any drawdown of the John Day Reservoir is anticipated. A minimum of daily monitoring during pre and post-drawdown and diligent monitoring of fish during a drawdown would also be required.

4. To assess possible effects of high density rearing of chinook salmon in Michigan raceways on infectious disease it is important to have control groups in Oregon raceways. This has become apparent from experiences that will be documented in the next annual report. This, of course, will need to be considered within the constraints imposed by limited water availability and production goals.

REPORT A

Umatilla Hatchery Monitoring and Evaluation

Prepared by:

Michael C. Hayes
Richard W. Carmichael
Shannon M. Focher
R. Wes Stonecypher

Oregon Department of Fish and Wildlife

UMATILLA HATCHERY MONITORING AND EVALUATION

INTRODUCTION

The Northwest Power Planning Council's Columbia River Basin Fish and Wildlife Program authorized construction of the Umatilla Hatchery in 1986. Measure 703 of the program amended the original authorization for the hatchery and specified evaluation of the Michigan type of rearing using oxygen supplementation to reach production goals of 290,000 lb of chinook salmon (*Oncorhynchus tshawytscha*) and steelbead (*Oncorhynchus mykiss*). The hatchery was completed in the fall of 1991. Partial justification for the hatchery was to develop considerable knowledge and understanding of new production and supplementation techniques. The use of the Michigan raceways in rearing at Umatilla Hatchery was selected because it could increase smolt production given the limited hatchery well water supply and allow comparison of Michigan raceways with the standard Oregon raceways. Results of testing the Michigan raceways will have systematic application in the Columbia Basin.

The Umatilla Hatchery is the foundation for rehabilitating chinook salmon and enhancing steelhead in the Umatilla River (CTUIR and ODFW 1990) and is expected to contribute significantly to the Northwest Power Planning Council's goal of doubling salmon production in the Columbia Basin. Hatchery production goals and a comprehensive monitoring and evaluation plan were presented in the UmatiIla Hatchery Master Plan (CTUIR and ODFW 1990). The Comprehensive Plan for Monitoring and Evaluation of Umatilla Hatchery (Carmichael 1990) was approved by the Northwest Power Planning Council as a critical adaptive management guide for fisheries rehabilitation in the Umatilla River. Monitoring and evaluation will be used to increase knowledge about uncertainties inherent in the fisheries rehabilitation and will complement the developing systematic monitoring and evaluation program.

The monitoring and evaluation goals are:

1. Provide information and recommendations for culture and release of hatchery fish, harvest regulations, and natural escapement that will lead to the accomplishment of long-term natural and hatchery production goals in the Umatilla River Basin in a manner consistent with provisions of the Council's Columbia River Basin Fish and Wildlife Program.

2. Assess the success of achieving the management objectives in the Umatilla River Basin that are presented in the Master Plan and the Comprehensive Rehabilitation Plan.

A substantial proportion of the production at Umatilla Hatchery will be produced in oxygen supplemented Michigan raceways. This rearing system has not been thoroughly evaluated to determine the effects on smolt-to-adult survival. In addition, the rearing strategies proposed for spring chinook salmon are different than normal. Production of yearling smolts will require an unusually extensive period of incubation in chilled well water. The monitoring and evaluation objectives for this report period were:

1. Document fish cultural and hatchery operational practices.

2. Monitor water quality parameters in a series of Michigan and Oregon raceways for each species reared.

3. Determine efficiency of Michigan raceways for producing chinook salmon and steelhead.

4. Determine and compare smolt migration performance and smolt to adult survival of chinook salmon and steelhead.

5. Determine straying by hatchery released fall chinook salmon.

6. Identify and compare the tagging and marking effects on smolt-to-adult survival of subyearling fall chinook salmon.

7. Coordinate in the development of a water quality sampling and monitoring in the UmatiIla River Basin.

8. Participate in planning and coordination activities associated with anadromous fish production, passage, monitoring, and evaluation in the UmatiIla River Basin.

9. Monitor and evaluate fish health at UmatiIla Hatchery.

Extensive background and justification for UmatiIla Hatchery monitoring and evaluation is presented in Carmichael (1990). In this report, we present a review of our activities and findings for the Umatilla Hatchery Monitoring and Evaluation Project from 1 November 1994 to 31 October 1995. We designed our program to evaluate the following categories: fish cultural practices, water quality monitoring, rearing performance and survival studies, fall chinook salmon straying studies, spring chinook salmon yearling and subyearling production evaluation, Bonneville Hatchery rearing, fall chinook salmon marking and tagging evaluation, creel surveys, and planning and coordination.

STUDY SITE

The Umatilla fish hatchery is located approximately seven miles from the town of Irrigon, Oregon (Figure 1). The hatchery is operated under a cooperative agreement among the Oregon Department of Fish and Wildlife (ODFW), the Confederated Tribes of the Umatilla Indian Reservation (CTUIR), the Bonneville Power Administration, the U.S. Fish and Wildlife Service, and the U.S. Army Corps of Engineers. A schematic diagram illustrating the raceway configuration for the UmatiIla Hatchery is displayed in Figure 2.

The Umatilla Hatchery was designed for salmonid production in oxygen supplemented Michigan raceways and in non-oxygen supplemented standard Oregon raceways. Specific information about the hatchery is available in the Umatilla Hatchery Master Plan (CTUIR and ODFW 1990) and in the Environmental Assessment Report (Bonneville Power Administration 1987). The Michigan system consists of eight series of three concrete raceways. Water flows from the upper raceway (A) to the middle raceway (B) and then to the lower raceway (C) within each series. Before the water enters each raceway, pure oxygen is supplemented through a pipe injection system. Physical characteristics of the raceways appear in Table 1. In each Michigan raceway there are nine baffles placed 10-l 1 ft apart to promote water movement across the bottom and aid in raceway cleaning. The raceways were occasionally brushed and were cleaned each day by vacuuming at the outflow screen three times per week. Because of water shortages, not all Michigan raceways were operated in 1994-95.

The Oregon system at Umatilla Hatchery consists of five series of two concrete raceways (Table 1). Water flows from the upper raceway (A) to the lower raceway (B). There are no cleaning baffles and raceways were broom cleaned once per week and occasionally vacuumed at the outlet. All 10 Oregon raceways were used in 1994-95.

Umatilla River steelhead were compared to stocks reared at Irrigon Hatchery. Oregon raceways at Irrigon Hatchery measured 30.5 m long and 6.1 m wide. Water height was kept at 117 cm. Physical characteristics of each raceway are presented in Table 1.

The Umatilla River and tributaries are located in Umatilla, Morrow, and Union counties, Oregon (Figure 1). Facilities include chinook acclimation ponds at Thornhollow (river mile 74) and Imeques C-mem-ini-kern (river mile 80), and steelhead acclimation ponds at Bonifer and Minthom springs.

METHODS

Fish Cultural Practices

We monitored fish cultural and hatchery operational practices at Umatilla Hatchery. Hatchery records were used to determine the number of eggs taken, egg mortality, fry mortality, and smolts released. Egg-to-smolt survival rates were calculated for fall chinook salmon, spring chinook salmon, and steelhead. Fish number, size at release, and location for Umatilla and Bonneville Hatchery production groups were determined from field sampling, hatchery records, and coded-wire tag release reports.

Water Quality Monitoring

Methods for water quality monitoring were the same as reported in the 1994 annual report (Hayes et al. 1995) with the following exceptions. Samples were collected weekly from early May 1994 to mid-May 1995 and readings from the gas pressure meter were recorded after a 5 minute stabilization period instead of 20 minutes.

Rearing Performance and Survival Studies

Except for the following modifications, methods used for chinook salmon and steelhead in 1994-95 were described in the 1992-1994 annual reports (Keefe et al. 1993, 1994; Hayes et al. 1995). Pre-release data was collected for Umatilla steelhead on the day they were released from the Minthom and Bonifer Springs acclimation ponds. Imnaba and Wallowa steelhead were raised in first pass ponds at Irrigon Hatchery and pre-release data were collected at the Wallowa and Big Canyon acclimation sites one week prior to release.

Smolt-to-adult survival estimates for all groups included age 2 and older fish. Survival was based on coded-wire tag return data from the Pacific States Marine Fisheries Commission (PSMFC) database and Three Mile Falls Dam return data.

Fall Chinook Salmon Straying

Fall chinook salmon released in the Umatilla River have strayed into the upper Columbia and Snake rivers in the past. To evaluate straying we examined records from releases made prior to and after the construction of Umatilla Hatchery. All information for marked Umatilla fall chinook salmon recovered at Ice Harbor Dam, Lower Granite Dam, Lyons Ferry Hatchery, Snake River spawning surveys, and at any other location in the Columbia basin were summarized.

To estimate the number of adult chinook salmon that would escape past Lower Granite Dam from releases made in the Umatilla basin, we used the following information and assumptions:

1. All data was based on coded-wire tag recoveries from the PSFMC database. Data was included from 1981-1989 brood years when the number of tag returns were greater than 35.

2. Percentages of salmon returning to the Columbia and Snake Rivers were based on the mean return rates for all tag groups within a year. From this we calculated a mean return rate across all years.

3. Snake River return rates represented the proportion of CWT's returning to the Columbia River that were collected in the Snake River.

4. Estimated escapement was based on current Umatilla and Bonneville Hatchery production levels (Umatilla Hatchery Basin Annual Operation Report 1994).

5. The fall-back adjustment of 50% was a conservative estimate based on data from Mendel (1993) who stated "As much as 62% of the loss of fish upstream of Ice Harbor Dam may be attributable to fall back at Ice Harbor.

6. The voluntary return rate of 22% to Lyons Ferry Hatchery was determined from the proportion of Umatilla fish collected at Lyons Ferry Hatchery and those returning to Lower Granite Dam during 1994 (LaVoy, personal communication). In previous years about 16% of the adult run at Ice Harbor voluntarily returned to Lyons Ferry; however, this was during a period when some fish were trapped at Ice Harbor Dam. No trapping was conducted at Ice Harbor in 1994 or is planned for the future.

7. The CWT and BWT loss rate of 2.2% was from 1994 Umatilla Hatchery data and was similar to proportions of adult chinook tag loss information in the Snake River.

8. We assumed a 90% tag detection rate at Lower Granite Dam.

9. No attempt was made to adjust for fall-back fish through the juvenile bypass facilities or passage through the transportation locks at Lower Granite Dam or Snake River spawners.

10. We assumed constant survival for all brood years.

Since 1992 most fish reared at Umatilla and Bonneville Hatcheries and released in the Umatilla River have been right ventral fin-clipped to identify strays. In addition, fall chinook salmon released in 1994 and 1995 were marked with a coded-wire tag or a blank-wire tag. To assure tagging accuracy, a subsample of approximately 300 fish per raceway were checked for tag retention a minimum of 14 days after tagging. We also evaluated the quality of the right ventral fin clip. A fm clip was categorized as: good if no fin or a small stub remained; fair if a fin stub of approximately 25% remained; poor when approximately 50% of the fin remained; and unclipped when more than 75 % of the fin remained.

Chinook Salmon **Subyearling and Yearliug Production Evaluation**

Except for the following modification, methods used in 1994-95 were described in the 1992-1994 annual reports (Keefe et al. 1993, 1994; Hayes et al. 1995). In 1994-95 pre-release data for some groups of fish reared at Bonneville Hatchery were collected at the acclimation sites. Fish were monitored as they were removed from the liberation trucks.

Effects of Tagging and Marking on Subyearling Fall Chinook Salmon

Methods used in 1994 were described in the 1992-1994 annual reports (Keefe et al. 1993, 1994; Hayes et al. 1995) except for the following modifications. In falI 1994 we examined fsh that returned to Three Mile Falls Dam on the UmatiIla River for coded wire tags, body tags, and fin clips. AlI chinook salmon except right ventral clipped or mini-jacks were examined with a Northwest Marine Technologies field detector or wand detector. All adipose clipped fish were sacrificed. Once the snouts were removed the fish were reexamined for body tags with the field and wand detectors. We used both detectors to examine fish so that the detection efficiency of each method could be determined. Unclipped fish or ftsh with the left ventral fin clipped were checked with the wand detector and released. Because of limitations of body tag detection we used coded-wire-tag recovery data to report returns for coded-wire-tag groups. Length frequency data was used to determine brood year origin for fish that were not coded-wire-tagged. Length frequency groups used were: 405-610 mm fork length at age 2,61 l-800 mm at age 3, and greater than 801 mm at age 4.

Bonneville Hatchery Salmon Evaluation

Except for the following modifications, methods used in 1994-95 were described in the 1992-1994 annual reports (Keefe et al. 1993, 1994; Hayes et al. 1995). Smolt-to-adult survival was calculated in the same manner as previously described for rearing performance and survival studies. No spring chinook salmon from the 1993 brood year and scheduled for release in fall 1994 were produced.

Creel Survey

For the second year we used handheld data recorders. Except for the following modifications. methods used in 1994-95 were described in the 1992-1994 annual reports (Keefe et al. 1993, 1994; Hayes et al. 1995). Because of the split fishing seasons, the 1994-1995 creel surveys on the Umatilla River were divided into three separate surveys:

1) Fishery: coho salmon and fall chinook salmon jacks (16-24 inches)
Date: 1 September to 30 November, 1994
Boundary: Stanfield Dam downstream to Highway 730 Bridge

2) Fishery: steelhead
Date: 1 September 1994 to 15 April, 1995
Boundary: The lower boundary of the CTUIR reservation downstream to Highway 730 Bridge

3) Fishery: spring chinook salmon
There was no spring chinook salmon fishery in 1995 because of low numbers of returning adults.

Statistical Analyses

The majority of tests comparing parameters between Michigan and Oregon systems and between passes within each system were analyzed using analysis of variance (ANOVA). For tests of a single brood year we used a nested ANOVA to separate sources of variation within the Michigan and Oregon systems. Nesting levels included system, raceway within system, and pass within raceway. The analysis of gill ATPase in spring chinook salmon also included a date effect and a date-by-pass interaction factor.

Sources of variation among brood years were separated into brood year, system, and/or pass. The evaluation of the chinook salmon stress response also included a treatment (control or treatment) effect and a treatment-by-system or treatment-by-pass interaction effect. Data with heterogeneous variances or listed as percentages were transformed as recommended (Sokal and Rohlf 1981).

In some tests percentage data were compared with the Kruskall-Wallis or Wilcoxon non-parametric test to make comparisons. Differences between pairs of means were tested by the Wilcoxon method.

Only raceways A and B were used in tests comparing the Oregon and Michigan systems. Raceway tests designed to examine differences within the Michigan system included A, B, and C passes. All other tests including planned comparisons of differences between means using the Sidak technique (Sokal and Rohlf 1981) were evaluated at an alpha level = 0.05.

RESULTS

Fish Cultural Practices

Umatilla Hatchery

Subyearliug Fall Chinook Salmon In 1994 fall chinook salmon were spawned from the Upriver Bright stock at Priest Rapids Hatchery. They were ponded on February 13, 1995 at Umatilla Hatchery in four Oregon raceways at 826.5 fish/lb. Each raceway received equal proportions from the combined egg takes to standardize donor parentage. On March 29 they were split into two Oregon raceways and six Michigan raceways at 212 to 214 fish/lb. On April 19, they were split for the final time into four Oregon and six Michigan raceways. On May 15 and 16 they were transported to the Imeques C-mem-in&kern and Thornhollow Facilities for acclimation before release into the Umatilla River. Rearing conditions, acclimation time, and release information are described in Tables 2 and 3. Egg-to-fry and egg-to-smolt survivals are described in Table 4.

Spring Chinook Salmon

Fall Release: The 1994 program eggs were spawned from the 1993 brood year Carson stock. In November 1993 approximately 1.4 million fertilized eggs were transferred to Umatilla Hatchery. Fertilized eggs were incubated at 42.5°F for seven days then the temperature was lowered to 38°F until hatch. Approximately 507,000 fry were ponded into one Oregon raceway in February 1994 at 679 fish/lb. In April they were split into two Oregon raceways for fall and spring releases at 103 and 10 1 fish/lb, respectively. In May fall release fish were split into two Oregon raceways at 76.0 fish/lb. In July they were split into two Oregon and three Michigan raceways with a 29.5 fish/lb (SE 1.0) average. In August they were transferred to four Oregon and six Michigan raceways at averages of

20.1 fish/lb (SE 0.6) and 21.9 fish/lb (SE 0.6), respectively. They remained in these raceways until transfer to Imeques C-mem-in&kern acclimation facility on October 26 and 27 for acclimation and release into the Umatilla River. The final weight averages for Oregon and Michigan raceways before transfer were 11.3 fish/lb (SE 0.9) and 12.5 fish/lb (SE 0.8), respectively. Rearing conditions, acclimation time, and release information are described in Tables 2 and 3. Egg-to-fry and egg-to-smolt survivals are described in Table 4.

Yearling Spring Release: The 1994 spring release program used 1993 brood year Carson stock. Fish were split in April from fry hatched later than fall release fish because of a longer and lower incubation temperature. In July two groups of fish were split into one Oregon raceway at 58.3 fish/lb and two Michigan raceways at 31.3 and 32.2 fish/lb. In August fish from the Oregon raceway were split into four raceways at an average of 41.9 fish/lb (SE 0.3). They remained in these raceways until transfer to Imeques C-mem-ini-kern acclimation ponds on February 21 and 22, 1995 for acclimation and release into the Umatilla River. The final weight averages for Oregon and Michigan raceways before transfer were 8.7 and 8.6 fish/lb, respectively. Rearing conditions, acclimation time and release information are described in Tables 2 and 3. Egg-to-fry and egg-to-smolt survival are described in Table 4.

Summer Steehead In 1994-1995 Umatilla River 1994 brood was used for steelhead. Approximately 234,000 fertilized eggs were incubated at 52°F at UmatilIa Hatchery. On August 15, 191,880 swim-up fry were ponded into one Oregon raceway at 328 fish/lb. In October they were split into two Oregon raceways at 71.4 fish/lb. In early November they were graded and split into three Michigan raceways at 21.4 to 39.8 fish/lb. On March 14 and 15, and April 15 they were transported to Bonifer and Minthom facilities for acclamation and released into the Umatilla River. Rearing conditions, acclimation times, and release information are described in Tables 2 and 3. Egg-to-fry and egg-to-smolt survivals are described in Table 4.

Irrigon Hatchery

Summer Steelhead Steelhead reared at Irrigon Hatchery are from Wallowa or Irnnaha broodstock. They were reared in standard-Oregon raceways. The 1995 steelhead maximum loading factors in Irrigon raceways were similar to loading factors in Michigan raceways at Umatilla Hatchery (Table 2). These fish were released in the Grande Ronde and Imnaha River systems.

Bonneville Hatchery

Yearling **Fall Chinook Salmon** Bonneville Hatchery has been rearing Upriver Bright fall chinook salmon stock in standard Oregon raceways since 1981 and releasing them into the Umatilla River since 1983. On March 8-l 1 1995, 228,000 smolts were transported to the Thomhollow acclimation facility and acclimated for 30 days before release into the Umatilla River. Rearing conditions, acclimation times and release information are described in Tables 2 and 3.

Yearling **Spring Chinook Salmon:** In 19921995 Bonneville Hatchery reared 1993 brood year spring chinook salmon (Carson stock) in standard Oregon raceways. Compared to rearing at Umatilla Hatchery, we found that maximum loading factors were greater than for Oregon reared fish but were similar to Michigan reared fish (Table 2). Three groups of fish from Bonneville were transferred to the Imeques C-mem-in&kern Acclimation facility and acclimated for 18, 30, and 37 days before being released into the Umatilla River (Table 3). Rearing conditions, acclimation dates, and release information are described in Tables 2 and 3.

Water Quality Monitoring

Comparisons of Oregon and Michigan Systems

We found some significant differences in water quality parameters for fish reared simultaneously in Michigan and Oregon systems (Tables 5-7). The minimum oxygen of 7.2 ppm was observed once in Michigan and Oregon raceways. The maximum oxygen was 17.9 ppm in a Michigan raceway. Mean oxygen was within acceptable limits and typically declined 1.0 to 3.0 ppm from raceway head to tail, in both rearing systems. There were significant differences in mean nitrogen between Michigan and Oregon systems (head and/or tail) for all groups. The minimum and maximum nitrogen recorded was 442 mmHg and 705 mmHg, respectively. The minimum individual total gas pressure was 699 mmHg and the maximum was 835 mmHg. The highest temperature observed in an individual raceway was 16.6 °C during the summer in a Michigan raceway that contained spring chinook salmon. The lowest individual measurement was 10.3 °C during the spring in a Michigan raceway that contained steelbead. The minimum individual pH measurement was 6.4 in an Oregon raceway that contained spring chinook salmon released in the fall and the maximum individual measurement was 8.8 in an Oregon raceway that contained yearling spring chinook salmon. Alkalinity ranged from 90 mg/L to 205 mg/L ($CaCO_3$). Comparisons of mean unionized ammonia between Michigan and Oregon systems were not significantly different. Ammonia ranged from 0.01 to 3.26 µg/L for all raceways.

Within Michigan System Comparisons

The only significant differences found between passes were pH at the head of the first and third pass raceways for fall chinook salmon and the ppm oxygen at the tail of first and third pass raceways for the spring chinook salmon released in the fall (Table 7). We observed that pH declined and unionized ammonia increased from 1st pass to 3rd pass raceways.

Rearing Performance and Survival Studies

The 1994 brood year of subyearling fall chinook salmon was the fourth consecutive brood reared at standard densities in Michigan and Oregon raceways. The following results summarize data for the 1994 brood year and the 1991 to 1994 brood years. Adult return data is incomplete.

Subyearling Fall Chinook Salmon

1994 Brood:

Rearing Performance: Fail chinook salmon from the 1994 brood year were ponded into outside raceways in February 1995 and split into Michigan and Oregon raceways at the end of March. Food conversion ratios were 1.30 for fish reared in each system at Umatilla Hatchery. Food conversion ratios averaged 1.37, 1.17, and 1.42 for fish reared in first, second, and third pass Michigan raceways. All fish were transferred fo upriver acclimation ponds prior to release and fish continued to grow during acclimation.

Smolt Con&ion: Oregon reared fish were significantly longer and heavier than Michigan reared fish at pre-release, but the Michigan reared fish had a greater condition factor (Table 8). We also observed significant differences in fish length, weight, and condition factor among passes within the same system (Table 9). At release from the acclimation ponds fish from both systems were larger and heavier and had a lower condition factor than fish measured at pre-release.

The proportion of subyearlings classified as smolts ranged from 10% to 19 % , and 4 % to 11% , in Michigan and Oregon raceways, respectively. Within Michigan passes the proportion of smolts ranged from 10% to 32%. Most other fish were classified as intermediate smolts at pre-release. Michigan reared fish suffered significantly more descaling and partial descaling than Oregon reared fish whereas fish reared in different Michigan passes suffered similar descaling (Table 10).

Smolt Migration Performance: The goal to brand 10,000 fish was achieved in each raceway (Table 11). The numbers of branded fish recovered at the John Day Dam from each raceway ranged from 22 to 39 and expanded to total counts from 83 1 to 1,621. Survival indices averaged 12 % for Michigan reared fish and 9% for Oregon reared fish. Survival indices for fish reared in different Michigan passes ranged from 10.5% to 14.5%. In 1995, 90% of the branded fish recoveries from the Umatilla River were captured at the John Day Dam less than 10 days after release. Length frequencies of fish recovered at the John Day Dam were similar to length frequencies of fish measured at release.

Smolt-to-Adult Survival: The goal to recognizably coded-wire-tag 30,000 fall chinook salmon was reached in two of ten raceways (Table 11). In the eight remaining raceways more than 28,000 fish were recognizably tagged. Tag retention ranged from 94.9% to 99.3% for all ten fall chinook salmon raceways.

1991 to 1994 Broods:

Rearing Performance: In four years of rearing, food conversion ratios averaged 1.20 in Michigan raceways and 1.07 in Oregon raceways. Oregon reared fish were significantly better at converting feed than Michigan reared fish in two of four years (Table 12). Fish reared in third pass Michigan raceways were slightly poorer at converting feed than fish in first and second pass raceways, but the differences were not significant. Food conversion ratios for fish reared in first, second, and third pass Michigan raceways averaged 1.21, 1.18, and 1.34 (Table 13).

Smolt Condition: Hatchery personnel attempted to produce fish that were the same size at release for all brood years. However. pre-release data showed Oregon reared fish from the 1993 and 1994 brood years were significantly longer and heavier than Michigan reared fish (Table 14). There were no significant differences in the lengths or weights of fish reared within Michigan passes (Table 15). Condition factors were not significantly different for any raceways at pre-release. However, the condition factors for 1994 brood year fish released from the acclimation ponds were markedly lower compared with previous brood years which were not acclimated.

Michigan reared fish suffered significantly higher descaling than Oregon reared fish in all years and higher partial descaling in two of four brood years (Table 16). The percent of fish that were descaled averaged 7 % for Michigan reared fish and 1% for Oregon reared fish for the four brood years. Descaling was similar for fish reared in different Michigan passes (Table 17). The percent of descaled fish averaged 8%, 6%, and 5% in first, second, and third pass Michigan raceways, respectively.

We found that the physiological stress responses of Michigan and Oregon reared subyearlings were comparable at pre-release and after transport. Baseline cortisol and glucose concentrations were similar for fish from each system and the treatment-by-system interaction was not significant for fish subjected to the standard stress at pre-release (Figures 3 and 4). Most variation at pre-release was explained by treatment and brood year effects. Noticeably high cot-tisol and glucose measurements were recorded for fish from the 1994 brood year. The stress responses of fish transported to the release site showed no major differences between Michigan and Oregon reared fish. Most variation was explained by a significant brood year effect. Contrary to tests conducted at the hatchery, cortisol concentrations of transported fish exposed to the standard stress increased little. Although there was a significant system effect for glucose concentrations of transported fish, there was only a small difference between Michigan and Oregon reared fish.

There was no significant difference in the stress responses of fish reared in different Michigan passes at pre-release and after transportation. Baseline cortisol and glucose concentrations were similar for fish reared in first, second, or third pass Michigan raceways (Figure 5). Most cortisol variation in hatchery tests was explained by a significant treatment effect but differences in the glucose response were explained by a significant brood year effect. No significant treatment-by-pass effects were found. The stress responses of fish transported to the release site were also similar. Most of the variability we observed was explained by a significant brood *year* effect. As in the system tests, we found little or no change in cortisol or glucose concentrations for transported fish that were exposed to the standard stress.

Smolt Migration Performance: Mean survival indices for Michigan and Oregon reared fish migrating to the John Day Dam varied significantly between brood years (Table 18). Although brood year explained 89% of the variation in the survival indices, there was also a significant, but smaller system effect. Survival indices to the John Day Dam were greater for Michigan reared fish in three out of four brood years. No significant differences in mean survival indices were found for fish reared in different Michigan passes (Table 19). Brood year explained most of the variation for these groups of fish.

We found significant differences in the time required by subyearlings to travel from release sites in the Umatilla River to the John Day Dam (Figure 6). The median travel time for 50% of the branded fish was 11 days for the 1994 brood migrating in 1995. In comparison, the median travel time for previous brood years ranged from 29 to 40 days. Examination of Columbia River flows measured at the John Day Dam for the primary migration period of June 1 to June 30 for each year showed that the highest average flows were in 1995. Average flows for the four migration years were: 189, 227, 187, and 280 kcfs for 1992 to 1995.

Smolt-to-Adult Survival: In 1994 we recovered the first information on returning jacks and adults from releases of subyearlings reared at Umatilla Hatchery. Release information was presented previously in this report and in earlier reports (Keefe et al. 1993, Keefe et al. 1994, Hayes et al. 1995). The return to Three Mile Falls Dam was 1,292 fish and consisted of returning adults from subyearling and yearling release groups. The run included 687 adults, 237 jacks, and 368 subjacks (< 15" FL). Approximately 94 adults, 24 jacks, and 51 subjacks were sacrificed to *collect* coded-wire tag information.

There were poor returns from 1991 brood subyearlings released in 1992. Only two adults were recovered at Three Mile Falls Dam (codes 071429 and 071437). One additional fish (code 071429) was harvested outside the Umatilla River. No jacks were recovered in 1993.

Returns of two-year old jacks from the 1992 brood were greater than for the 1991 brood. We estimated that 13 coded-wire tagged fish (6 tag groups) returned to Three Mile Falls Dam in 1994. The average fork length of these fish was 497 mm (range 415 mm to 555 mm). These fish were originally released as 86 mm (FL) subyearlings in May 1993. Eight additional coded-wire tag recoveries of the 1992 brood were made outside the Umatilla basin. Preliminary return estimates are provided in Table **20.**

Fall Release Spring **Chinook Salmon**

Rearing Performance: Spring chinook salmon from 1993 brood were released in November 1994. Preliminary information on the 1993 brood was included in the 1994 annual report. Final food conversion ratios were slightly higher in Michigan raceways with the highest conversions in the first pass (Table 21).

Smolt Condition: At pre-release Michigan reared **fish** were significantly longer, heavier, and had higher condition factors than Oregon reared **fish** (Tables 22-23). Michigan reared fish had slightly **higher** scale loss than Oregon reared fish (Table 24). Baseline cortisol and glucose responses in Michigan and Oregon reared **fish** were similar (Figure **7).** Transporting both Oregon and Michigan reared **fish** significantly increased their plasma cortisol response to stress (Figure 7). However, plasma glucose in Michigan and Oregon reared fish after transport did not significantly increase. There was no significant difference in cortisol and glucose among fish reared within Michigan passes (Figure 8). Activity of **ATPase** in both Oregon and Michigan raceways significantly decreased before transfer, during acclimation, and before release (Figure 9).

Smolt-to-Adult Survival: Approximately **35,000** fish from each raceway were fin clipped and implanted with coded wire tags (Table 25). Tag retention was above 97 % for all raceways. Spring chinook salmon from the 1991 and 1992 brood years were released in the fall of 1992 and 1993. However, there have been no coded wire recoveries or adult returns for fish reared in either Michigan or Oregon raceways through 1995.

Subyearling Spring Chinook Salmon

The subyearling program has been temporarily discontinued because of an egg shortage. No adults have been recovered from 1991 brood subyearlings released in 1992. Recovery information will be included in future reports.

Summer Steelbead

Rearing Performance: Because **fish** were graded before ponding, length, weight, and condition factors were monitored but not tested (Table 26). The large grade fish were reared in the third pass raceway and the small grade fish were reared in the first pass raceway. Mean dry food conversion ratios were similar for Umatilla steelhead reared in different Michigan passes, but lower than steelhead reared at Irrigon Hatchery (Table 27).

Smolt Condition: Pre-release length, weight, and condition factor data are presented in Table 26. The **Imnaha** and **Wallowa** steelhead reared at Irrigon Hatchery were similar in length and weight, but had a higher condition factor than the Umatilla steelhead reared at Umatilla Hatchery. Umatilla steelhead that were classified as **smolts** were 23 **%**, 45 **%**, and 61 **%** in first, second, and third pass raceways, respectively. Descaling information is presented in Table 28. We found that 21-52% of the steelhead were characterized as descaled or partially descaled. Fish from the second pass raceway had the least amount of descaling. Only Umatilla stock steelhead were examined for fin erosion. All fish possessed some degree of fin erosion (Table 29) and at least 81% of the fish in all raceways were classified as having light caudal fin erosion. Damage to the dorsal fin was highest in the first pass raceway where 96% of the fish suffered moderate or severe erosion.

Smolt Migration Performance: Approximately 10,000 steelhead were branded in each raceway (Table 30) and the percentage of readable brands ranged from 77 % to 88 %. Brand recoveries at John Day Dam were low compared with previous years and ranged from 3 to 6 fish for the three raceways resulting in an expanded passage count of 161 to 252. Survival indices for raceways M8A, M8B, and M8C were 2%, 3%, and 2%, respectively.

Steelhead reared in raceways M8C and M8B were released from acclimation ponds on April 11 and 13, respectively. The first branded fish were recovered at John Day Dam 22 days after release from M8C and 20 days after release from M8B. Steelhead from raceway M8A were released on May 12 and the first branded fish was recovered at John Day Dam on May 8, four days prior to release. Therefore, some Juvenile steelhead may be escaping from Bonifer Springs acclimation facility before the release date. The cumulative brand recoveries reached 50% on 2 June 1995 for all three groups despite different release dates. The last observation was 7 June 1995.

Smolt-to-Adult Survival: We marked more than 18,000 steelhead in each Michigan raceway in 1995 (Table 30). Adult return rates from the 1991 brood were poor for fish reared in first and second pass raceways compared with fish reared in the third pass raceway (Table 31). Current estimates of total survival for the 1991 and 1992 broods range from 0.01% to 0.34%. Preliminary analysis of smolt-to-adult survival data showed that 24 coded-wire-tags were recovered in Columbia River fisheries from 1993 to 1995. Total survival for the 1991 and 1992 brood Imnaha and Wallowa steelhead that were acclimated prior to release ranged from 0.004%-0.21%. Run timing for adult steelhead returning to Three Mile Falls Dam on the Umatilla River during 1993 to 1994 and 1994 to 1995 was similar for wild and hatchery fish (Figure 10).

Spring Chinook Salmon Yearling and Subyearling Production Evaluation

Rearing Performance

Umatilla Subyearlings: Because of an egg and broodstock shortage, no subyearlings were produced in 19941995.

Umatilla Yearlings: Spring chinook salmon from the 1993 brood year were the first group of yearlings simultaneously reared in Michigan and Oregon raceways. Rearing performance data is presented in Table 32. Because of a change, fish originally intended for fall release were rescheduled for spring release and reared in Michigan raceways. These fish were ponded in Oregon raceways in June 1994 and transferred to Michigan raceways. Attempts to slow the growth of fish reared in Michigan raceways led to a birnodal length frequency distribution. However, by the end of October the mean length and weight of Michigan reared fish was similar to Oregon reared fish. Growth in the two systems was similar for the remainder of the rearing cycle. Growth was also similar for fish reared in first and second pass raceways within the Michigan and Oregon system raceways (Tables 33-34). The mean food conversion ratio was 1.65 for Oregon reared fish and 1.87 for Michigan reared fish. These values were not significantly different.

Bonneville Yearlings: The rearing performance of Bonneville yearlings was not monitored except for food conversion ratios. The ratio for yearlings raised at Bonneville Hatchery was 1.57

Smolt Condition

Umatilla Yearlings: We found a significant difference in mean condition factor, but no difference in mean weight for Michigan and Oregon reared fish (Table 32). Mean lengths were significantly different and a bimodal frequency distribution that developed in fall 1994 was still evident for Michigan fish at pre-release (Figure 11). Fish grew during the acclimation period. Final release parameters for fish reared in different passes within systems were also similar (Table 33-34). Combined proportions of descaled and partially descaled fish were approximately 12% greater for Michigan reared fish compared to Oregon reared fish (Table 36). Fish within first pass Michigan and Oregon raceways suffered higher descaling than fish reared in second pass raceways. At pre-release 29240% and 38%-55% fish were classified as smolts for Michigan and Oregon reared fish, respectively. Most fish were classified as intermediate smolts. The specific activity of ATPase varied significantly by date (Figure 12), but did not increase proportionally to release date. No significant system or date-by-system interaction effects were found.

Bonneville Yearlings: Bonneville yearlings averaged 31 to 35 g at the pre-release evaluation (Table 35). Only 2 % to 7 % of Bonneville yearlings were classifted as smolts and nearly all other fish were intermediate smolts. No significant descaling was found for yearlings (Table 36).

Smolt Migration Performance

Umatilla Yearlings: Approximately 5,000 yearlings from each raceway were branded to monitor migration rate and success to the John Day Dam (Table 37). Michigan and Oregon reared fish were combined in acclimation ponds at Imeques-c-mem-ini -kem for 20 days and released into the Umatilla River on March 13, 1995. Survival indices between Michigan and Oregon reared fish were not significantly different and the combined survival index for all Umatilla releases was 13.9 %. Branded fish were identified at the John Day Dam beginning on April 7 and ending on May 21, 1995 (Figure 13). The median time required to recover 50% of all brands was 48 days after release and Oregon reared fish traveled faster than Michigan reared fish.

Bonneville Yearlings: We branded more than 4,800 yearlings in each of two raceways (Table 37). Yearlings were transferred to Imeques-c-mem-i&kern and acclimated for 30 days before release on April 2 1, 1995. The mean survival index for two raceways was 10.8 %. The first and last dates that fish were observed at the John Day Dam was May 4 and May 19 (Figure 13). The time required to recover 50% of all brands was 24 days after release.

Smolt-to-Adult Survival

Tag retention for yearlings marked at Umatilla and Bonneville Hatcheries ranged from 95.1% to 99.7 % and 87.7 % to 98.1% , respectively (Table 37). Adult returns from previously released brood years are incomplete. No coded-wire tags have been recovered for subyearlings from the 1991 or 1992 brood years. Only 1 yearling recovery has been made. One 3 year old jack from the 1991 brood reared at Bonneville Hatchery was recovered at Three Mile Falls Dam in 1994. Data from the 1995 run was not available.

Fall Chinook Salmon Straying

Washington Department of Fish and Wildlife estimated that 268 fall chinook salmon from Umatilla River releases strayed to Lower Granite Dam in 1994 (LaVoy 1995). Of these fish, 175 adults (>22 inches TL) and 10 jacks (12-22 inches TL) were estimated to have escaped past Lower Granite Dam. Most strays originated from subyearlings reared at Irrigon Hatchery and released in the Umatilla River prior to the construction of Umatilla Hatchery.

We predicted the number of strays resulting from future releases of fall chinook salmon in the Umatilla River to meet Section 7 consultation under the Endangered Species Act. We estimated that an average of 26-3 1 fish would escape past Lower Granite Dam from releases in 1995 and 1996 (Table 39). Mean stray rates for CWT groups entering the Columbia River and recovered in the Snake River averaged 14 % for subyearlings and 5 % for yearlings.

Effects of Marking on Subyearling Fall Chinook Salmon

This was the second year that we monitored adults returning from the subyearling fall chinook salmon marking study initiated in 1991 at Irrigon Hatchery and continued in 1992 and 1993 at Umatilla Hatchery (Keefe et al. 1993, 1994 and Hayes et al. 1995). We found that the efficiency of the wand for detecting body-tags was only 50% compared to the field detector. However, use of the field detector was awkward and not reliable. Table 40 summarizes the data collected. Survival data for the 1990-1992 brood years is incomplete.

Bonneville Hatchery Salmon Evaluation

Approximately 227,000 fall chinook salmon from the 1993 brood year were reared as yearlings in seven raceways at Bonneville Hatchery. Food conversion ratios were 1.31 for thii group. About 25,000 fish were marked AD+RV+CWT in each of two raceways (codes 070658 and 070659). Tag loss was 3.7 % to 6.3 %. The remainder of the fish in the seven raceways were marked AD+RV + blank-wire tag. The tag loss for these fish ranged from 2.7 % to 9.6 %. These fish were transported to the Thomhollow acclimation ponds from March 8 to March 11, 1995 and released on April 7, 1995. The average size at release ranged from 7.8 to 8.2 fish/lb.

Adult returns of fall chinook salmon released as yearlings have been monitored since Umatilla Hatchery began in 1992. Only 6 adults, all age four, have been recovered from the 1990 brood (codes 075618 and 075619). Recoveries from the 1991 brood (codes 071460 and 071461) consist of 6 age two subjacks (< 15" FL) and 10 age three jacks. A number of yearlings from the 1992 brood released in spring 1994 were recovered in the fall as subjacks (codes 070252 and 070255). Most of these fish were recovered at Three Mile Falls Dam. Their average length was 348 mm (N=45) with a **range** of 310 mm to 402 mm FL.

Spring chinook salmon were reared at Bonneville Hatchery and released into the Umatilla River in November 1992. Only three adult tags (three codes) were collected from the 1994 run.

Creel Survey

Catch statistics and coded-wire-tag recovery information for 1994-95 creel surveys are reported in Tables 32 to 35. During the 1994 fall chinook and coho salmon fishery on the Umatilla River, 596 anglers fished an estimated 2,898 hours between the mouth of the river and Three Mile Falls Dam. They caught 250 chinook salmon, 75 coho salmon, and harvested 73 and 33 respectively, for a catch rate of 9 hours per fish (0.11 fish per hour). The fall chinook harvest was composed of 51% mini-jacks (< 15"), 35% jacks, and 14% adults.

The summer steelhead fishery was open from 1 September 1994 through 15 April 1995. Twenty of the scheduled creel days were not sampled because of flooding and were considered to be zero effort and zero catch. During this period 1,070 anglers fished an estimated 6,172 hours between the mouth and the lower boundary of the Confederated Tribes of The Umatilla Indian Reservation. Anglers harvested 61 of the 257 steelhead for a catch rate of 24 hours per fish (0.042 fish per hour). We did not conduct the creel survey between Three Mile Falls Dam and Stanfield Dam because there was not a significant amount of pressure observed during the 1994-95 season. However, spot checks did indicate occasional angling in this area.

The Umatilla River was not opened in 1995 for a spring chinook salmon fishery because of the low number of adults that returned to Three Mile Falls Dam. The majority of anglers that fished the Umatilla River were residents of Umatilla and Morrow counties.

Planning and Coordination

The research monitoring and evaluation team participated in planning and coordination activities for the Umatilla Basin. We cooperated with CTUIR in estimating adult returns and sacrifice rates of coded-wire-tagged fish. We planned and participated extensively in hatchery production and worked cooperatively with hatchery personnel and CTUIR teams to collect data from returning adults at Three Mile Falls Dam. We met regularly with several groups as part of the Umatilla Monitoring and Oversight Committee. Project personnel also participated in the section 7 consultation process with the National Marine Fisheries Service and the Bonneville Power Administration to estimate fall chinook salmon stray rates. We developed a model to estimate strays using catch and escapement information from coded-wire tagged fish that were released in the Umatilla River.

DISCUSSION

Fish Cultural Practices

Water shortages have reduced overall fish production, but by using Michigan raceways total production has been increased over production that would have been possible with standard rearing **methods.** The egg-to-smolt survival for fall chinook salmon was equal to the value (64%) predicted in the master plan (CTUIR and ODFW 1990). The egg-to-smolt survival of spring chinook salmon released in the spring was above predicted goals (CTUIR and ODFW 1990) and greater than the fall release strategy. Steelhead egg-to-smolt survival was greater than the predicted 53 % value used for production planning (CTUIR and ODFW 1990).

Achievement of size at release goals was variable for groups released in 1994-1995. Fall chinook salmon released in 1995 were smaller than the target size of 60 fish/lb in both Michigan and

Oregon raceways. However, spring chinook salmon released in both spring and fall were larger than the 12 fish/lb release goals. Spring chinook salmon yearlings raised at Bonneville Hatchery as controls were also larger than release goals. Steelhead released in 1995 were equal or close to the projected release goal of 5 fish/lb.

Water Quality Monitoring

Measurements of water quality parameters at Umatilla Hatchery continued to show few differences between systems. Most differences were small and are not considered biologically significant. Alkalinity dropped below the optimum recommended range of 120-400 mg/l (Piper et al. 1982) repeatedly in the steelhead and yearling spring chinook salmon raceways . Maximum dissolved oxygen in the supplemented Michigan raceways were below levels that cause damage to fish because of chronic exposure (Colt et al. 1991). Critical concentrations of unionized ammonia, 0.0125 ppm, were recorded on one occasion in a Michigan steelhead raceway. High loading in Michigan raceways could increase total gas pressure (Colt et al. 1991). This can increase carbon dioxide and have detrimental effects on fish. However, we observed no statistical differences in total pressure at the head or tail of raceways between systems or among passes in the Michigan system. Water quality at Irrigon and Bonneville hatcheries was not monitored, so we made no comparisons.

Rearing Performance and Survival Studies

System Evaluations

Subyearling fall chinook salmon 1991-1994: Fish reared in high-density, oxygen supplemented Michigan raceways performed as well as Oregon fish. Although Michigan reared fish had lower food conversion ratios and higher percentages of descaling, stress and migration tests indicated that Michigan reared fish performed as well as Oregon reared fish. A study at Eagle Creek Hatchery showed that coho salmon reared at higher densities had similar cortisol responses (Schreck et al. 1985). Because crowding is generally considered to be stressful, fish may need to be reared at greater densities than we tested before differences could be detected.

Juvenile migration success to the John Day Dam for the 1994 brood must be viewed with caution. Other studies have also shown that flow is a primary factor influencing salmon migration (Bergren and Filardo 1993, Maule et al. 1994). However, other factors may have influenced the performance of the 1994 brood. They were released at a larger size than previous groups and were the first brood to be acclimated; therefore, direct comparisons were not valid. Also, the lower condition factor indicated that acclimated fish were more physiologically developed for migration than previous broods. Condition factor has been found to be highly correlated with ATPase activity in spring chinook salmon (Beeman et al. 1991).

To date, adult returns inidcate the smolt-to-adult survival of the 1991 brood was poor. These fish were released in a below average water year for the Umatilla Basin. Because of low flows in 1992 it was necessary to trap 1.7 million fish and haul them to suitable release locations (Zimmerman et al. 1992) In comparison, in 1992 less than 200,060 fish were trapped and hauled (Zimmerman et al. 1993). The abundance of age 2 jacks indicates that adult recoveries from the 1992 brood will be more successful. Final conclusions regarding the effectiveness of Michigan and Oregon rearing systems cannot be determined until adult recoveries are complete.

Spring chinook salmon: Spring chinook salmon were reared in Michigan and Oregon systems as 1991 brood subyearlings that were released in the spring and as 1992 and 1993 broods released in the fall. Rearing and performance of these groups was similar to fall chinook salmon (Keefe et al. 1993, 1994; Hayes et al. 1995). In general, .Michigan reared fish were more descaled and converted food more poorly than Oregon reared fish. Ewing et al. (1994) also reported lower food conversions for spring chinook salmon reared in Michigan raceways. We found that fish from both systems responded similarly to stress. Smolt-to-adult survival will be evaluated when coded-wire tag recoveries are complete.

Within System Evaluation

Chinook salmon: Few differences have been found in rearing and performance parameters for fish reared in different passes of Michigan or Oregon raceways. Only occasional differences in fish size, condition, stress response, or survival to the John Day Dam were observed among passes. Fish in some third pass raceways have converted significantly less food.

Steelhead: Brand recovery data may not accurately indicate smolt survival to the John Day Dam in 1995, but the affect of Columbia River flow on brand counts is unknown. High water at the John Day Dam may have reduced collection efficiencies as steelhead spilled over the crest. Flows in the Umatilla River were above average in 1995. In the past, adult counts of wild steelhead at Three Mile Falls Dam have coincided with Umatilla River flows two years prior to adult returns (CTUIR 1995).

Tag return data for 1991 and 1992 brood steelhead released in the Umatilla River is incomplete. However, return data indicates greater survival for the 1992 brood compared to the 1991 brood. Returns of one-ocean steelhead (1992 brood) from UmatiIla Hatchery tag groups ranged from 0.02% to 0.34% compared to 0.00% to 0.15% for combined one and two-ocean fish from the 1991 brood. This pattern was also observed for 1991 brood steelbead released in the Imnaha and Wallowa Rivers (Flesher personal communication). Performance of fish from the 1991 brood year at Umatilla Hatchery may not be representative of the effectiveness of the Michigan rearing system. Those fish were reared at higher densities and suffered greater fin erosion than later broods (Keefe et al. 1993).

The smolt-to-adult survival goal of 2.7% set in the UmatiIla Hatchery Master Plan (1990) has not been attained, but despite poor survival for the initial release from Umatilla Hatchery, there are some encouraging signs. Aspects of the life history, such as run timing, are similar for hatchery and wild adult steelhead. Also, greater smolt-to-adult survival rates for fish reared in third pass raceways may provide clues to improving the steelhead program. Although steelhead from each raceway were released at similar sizes, other parameters of the rearing and release profile were different for first, second, and third pass raceways. Fish reared in the third pass raceway were large grade, acclimated at Bonifer Springs, and released in mid-April while medium grade fish from the second pass raceway were acclimated at Minthom Springs. Small grade fish from the first pass raceway were also acclimated at Bonifer Springs, but were released in mid-May. If fish released in May continue to do poorly compared to groups released in April, time,at ielease dates should be reevaluated.

Spring Chinook Salmon Yearling and Subyearling Production Evaluation

Yearlings were simultaneously reared in Michigan and Oregon raceways for the first time in 1994-1995. Data showing that Michigan and Oregon reared fish developed and migrated similarly indicated that yearlings can be successfully produced in Michigan raceways- However, some problems did exist. Michigan reared fish suffered higher descaling and converted less food than Oregon reared salmon. Also, Michigan reared fish had a greater incidence of bacterial kidney disease than Oregon reared fish (see Report B, this volume). The extent to which these problems will affect smolt-to-adult survival is unknown.

As reported previously, ATPase changed little during rearing (Keefe et al. 1993, 1994; Hayes et al. 1995) and the smolt development of spring chinook salmon could not be predicted with increases in ATPase. In contrast, visual assessments indicated that most yearlings were smoking at release and these fish rapidly migrated through the Umatilla River after released (Knapp, personal communication).

River flow or release date may be important determinants of migration rate. In 1994 we found that Bonneville and Umatilla reared yearlings released into the UmatiIla River at the same time arrived at the John Day Dam simultaneously (Hayes et al. 1995). However, in 1995 Bonneville reared yearlings that were released one month later than Umatilla reared yearlings, migrated more quickly and survived as well as Umatilla yearlings.

Fall Chinook Salmon Straying

The estimated escapement of 175 stray Umatilla origin fall chinook salmon past Lower Granite Dam was greater than in previous years. Although we did not calculate statistical confidence intervals for this estimate, we believe it is imprecise because of the large marked to unmarked expansion factors for some groups (1:25). Many of the adult fish estimated to stray above Lower Granite Dam were from groups that were produced at Irrigon Hatchery and released in the lower Umatilla River at low marking rates. Since 1992. UmatiIla Hatchery production groups have been released at up-river sites and the marked to unmarked rates were 1: 10. This should allow for more accurate straying estimates.

A number of changes have been implemented through the adaptive management process in the UmatiIla Basin to reduce future straying. The following list is a summary of activities that are being implemented to reduce straying. Some information comes from Rowan (1995).

1. Marking and Tagging - The marking and tagging program will improve our ability to identify and collect Umatilla Hatchery fish at mainstem dams and other collection locations. Starting with the 1994 release year, all Umatilla River fish have been right ventral fin clipped and marked with a magnetized wire tag. Tag retentions have averaged 97.8 % and only 1.9% of the subyearlings were unclipped.

2. Increase in attraction flows - Some straying may occur because of low attraction flows at the mouth of the Umatilla River. Phase I of the Umatilla Basin Project has been completed to provide increased flows during the adult return season. Phase II will be completed in 1997 and will further increase flows at the mouth during the adult return season.

3. Release site/Acclimation - Data from subyearling releases in 1990 and 1991 suggests that releases in the upper Umatilla River reduce straying. Currently, 42% of the recoveries are

made in the Umatilla River compared to 8% for earlier releases. Starting with the 1994 brood year, all fish will be acclimated and released in the upper river.

4. Stock - If adult straying has a genetic component, production from Umatilla brood stock may help to reduce strays. Permanent adult fall chinook salmon broodstock holding and spawning facilities are scheduled for completion in 1996 and progeny from Umatilla broodstock will be produced as the program is developed.

Effects of Marking on Subyearling Fall Chinook Salmon

Marking effects on subyearling fall chinook salmon are being evaluated to assess the potential of body tags and ventral fm clips as marks for mass production purposes. Adult return data is incomplete and no conclusions about marking effects on smolt-to-adult survival can be made at this time. We are not satisfied with the detection capabilities of the wand or field detector and believe some body tags were not counted. A prototype tube detector with greater detection capability will be available in the future. It will be used to examine all fish and possibly used to modify previous counts made with the wand and field detectors.

Bonneville Hatchery Salmon Evaluation

Total smolt-to-adult survival from previous releases of yearling fall chinook salmon were as high as 3 % (Rowan 1995). Total survival for the 1990 brood has been lower and may reflect unfavorable environmental conditions. The recovery of subjacks at Three Mile Falls Dam suggests that some fish residualize in the Columbia River. Discussions with Washington Department of Fish & Wildlife biologists (Mendel, personal communication) indicate that yearling chinook salmon released from Lyons Ferry Hatchery also return as age 2 subjacks in the same year that they were released. Yearling and subyearling release strategies will be evaluated as return data is recovered.

Creel Survey

The numbers of jack fall chinook salmon and coho salmon passing Three Mile Falls Darn in 1994 were 237 and 1,047, respectively. The estimated harvest below the dam represented 10% of the fall chinook jack salmon run and 3% of the coho salmon run to Three Mile Falls Dam. Angling pressure in 1994 (966 h/month) was similar to the average for the two previous seasons (994 hrs/month). Anglers spent an additional 1.6 hours fishing per trip in 1994.

Counts of adult steelhead passing Three Mile Falls Dam were below the average for the previous 10 years (1,531 and 2,083 fish, respectively). Fifty-seven percent of the run consisted of wild steelhead compared to an average of 76% for the past five years. Although the majority of the run passed the dam before 15 April 1995. the high number of flood days may have caused a decline in angling. Fishing pressure in 1994-95 was low (823 h/month) compared to the previous two years (mean = 1162 h/month). However, catch rates in 1994-95 (0.042) were greater than in 1993-94 (0.014 fish/b) but less than rates on the lower Grande Ronde River (0.047 fish/h) and the lower Wallowa River (0.069 fish/h) (Flesher et al. 1995). The estimated steelhead harvest in the Umatilla River was 3.9% of the total 1994-95 run to Three Mile Falls Dam. The estimated steelhead catch from punch cards in fall 1994 of 73 fish closely mirrored the estimated catch (94 ± 41) from creel survey data. The punch card estimate was 85% of the total fish harvested for the 1993-94 season. Data from 1995 punch card estimates were not available.

There was no spring chinook salmon' fishery in 1995. The run to Three Mile Falls Dam in 1995 was 496 fish. Adult returns of spring chinook salmon to Three Mile Falls Dam from 1989 to 1995 have ranged from 163 to 2,190 fish.

ACKNOWLEDGMENTS

We acknowledge the assistance of Oregon Department of Fish and Wildlife personnel at Irrigon and Umatilla Hatcheries. We are indebted to the coded-wire-tagging supervisors, marking supervisors, and tagging and marking crews who worked tirelessly to mark more than 3 million **fish** at UmatiIIa Hatchery. We thank fish liberation personnel who cooperated in transportation, scheduling and sampling of fish for experiments. Biologists from the Confederated Tribes of the Umatilla Indian Reservation and the Oregon Department of Fish and Wildlife helped us collect data at the Three Mile Falls Dam and at acclimation ponds. We received considerable assistance from ODFW employee, PhiI Flanders who designed our creel data entry program. We give special thanks to Candi Hall who collected the majority of the creel survey information and assisted in field sampling and data entry. In addition, we were assisted by Becky Banghart and John Meriwether. We would also like to thank Jerry Bauer for his continuous support.

LITERATURE CITED

Beeman, J.W., D. W. Rondorf, J.C. Faler, P.V. Haner, S.T. Sauter, D.A. Venditti. 1991. Assessment of smolt condition for travel time analysis. Bonneville Power Administration Annual Report.

Berggren, T.J. and M.J. Filardo. 1993. An analysis of variables influencing the migration of juvenile salmonids in the Columbia River basin. North American Journal of Fisheries Management. 13:48-63.

Bonneville Power Administration. 1987. Environmental assessment of Umatilla Hatchery. Office of Power and Resources Management, Portland, Oregon.

Carmichael, R. W. 1990. Comprehensive plan for monitoring and evaluation of Umatilla Hatchery. Pages 60-90 *in* Umatilla Hatchery Master Plan. The Confederated Tribes of the Umatilla Indian Reservation and Oregon Department of Fish and Wildlife. Submitted to the Northwest Power Planning Council, Portland, Oregon.

Colt, J., K. Orwicz, and G. Bouck. 1991. Water quality considerations and criteria for high-density fish culture with supplemental oxygen. Pages 372-385 *in* J. Colt and R. J. White, editors. Fisheries Bioengineering Symposium. American Fisheries Society, Bethesda, Maryland.

CTUIR (Confederated Tribes of the Umatilla Indian Reservation) 1995. Umatilla Basin Natural Production Monitoring and Evaluation. Prepared for Bonneville Power Administration (Annual progress report).

CTUIR (Confederated Trii of the Umatilla Indian Reservation) and ODFW (Oregon Department of Fish and Wildlife). 1990. The Umatilla Hatchery Master Plan. Submitted to the Northwest Power Planning Council, Portland, Oregon.

Ewing, R.D., Fustish, C.A., Johnson, S.L. and Pribble, H.J. 1980. Seaward migration of juvenile chinook salmon without elevated (Na+K)-ATPase activities. Transactions of the American Fisheries Society., 109: 349-356.

Ewing, R.D., SK. Ewing, and J.E. Sheahan. 1994. Willamette oxygen supplementation studies. Annual progress report. Bonneville Power Administration Report.

Flesher, M.W. 1993. Summer steelhead creel surveys on the Grande Ronde, Wallowa, and Imnaha Rivers for the 1990-91 run year. Progress report, Oregon Department of Fish and Wildlife.

Keefe, M.L., R. W. Carmichael, R.A. French, W .J. Groberg, and M.C. Hayes. 1993. Umatilla hatchery monitoring and evaluation. Annual progress report to Bonneville Power Administration, Portland, Oregon.

Keefe, M.L., R.W. Carmichael, SM Focher, W.J. Groberg, and M.C. Hayes. 1994. Umatilla hatchery monitoring and evaluation. Annual progress report to Bonneville Power Administration, Portland, Oregon.

Maule, A.G., J.W. Beeman, R.M. Schrock, P.V. Hamer. 1994. Assessment of smolt condition for travel time analysis. Bonneville Power Administration Report 87-401

Messmer, R.T.. R.W. Carmichael, M.W. Flesher. and T.A. Whitesel. 1991. Evaluation of Lower Snake River Conpensation Plan facilities in Oregon. Oregon Department of Fish and Wildlife, Fish Research Project AFF1-LSR-92-10, Annual Progress Report, Portland.

Nielsen, L.A., D.L. Johnson, and S.L. Lampton. 1983. Fisheries techniques. American Fisheries Society, Bethesda, Maryland.

Rowan 1995. Minthorn Springs summer juvenile release and adult collection facility. Annual progress report to Bonneville Power Administration, Portland, Oregon.

Schreck, C.B., R. Patino, C.K. Pring, J.R. Winton, and J.E. Holway. 1985. Effects of rearing density on indices of smoltificaticn and performance of coho salmon. Aquaculture 45:345-358.

Sokal, R.R. and F.J. Rohlf. 1981. Biometry. W.H. Freeman and Company, New York

Standard Methods for the Examination of Water and Waste Water. 1981. 15th Edition.

Zimmerrnan, B.C., G.A. James, B. Duke, and K. Witty. 1992. Trapping and transportation of adult and juvenile salmon in the lower Umatilla River in northeast Oregon. Annual progress report. Bonneville Power Administration Report

Zimmerman, B.C. and B. Duke. 1993. Umatilla River basin trap and haul program. Annual progress report. Bonneville Power Administration Report.

Table 1. Physical characteristics of the Oregon and Michigan raceways located at Umatilla, Irrigon, and Bonneville Hatcheries.

System	Hatchery	Length ft (m)	Width ft (m)	Water depth ft (m)	Volume ft^3 (m^3)	Flow gpm (lpm)
Michigan	Umatilla	91.0 (27.7)	9.0 (2.7)	2.5 (0.8)	2252 (64)	937 (3549)
Oregon	Umatilla	91.0 (27.7)	18.8 (5.7)	3.5 (1.1)	5962 (169)	1250 (4735)
Oregon	Irrigon	100.0 (30.5)	20.0 (6.1)	3.9 (1.2)	7833 (222)	1539 (5830)
Oregon	Bonneville	80.0 (24.4)	20.0 (6.1)	3.0 (0.9)	4800 (136)	650 (2462)

Table 2. Rearing conditions in Oregon and Michigan raceways at Umatilla, Irrigon, and Bonneville Hatcheries for fish released in to the Umatilla River during 1994-1995. Conditions described are immediately prior to release from the hatchery.

Race-species, release strategy	Brood year	System	Maximum density (lb/ft^3)	Maximum loading factor (lb/gal/min)
		Umatilla Hatchery		
Fall Chinook salmon: Subyearlings	1994	Michigan	1.5-1.9	3.7-4.5
		Oregon	0.4-0.6	1.9-2.9
Spring Chinook salmon: Yearlings Fail release	1993	Michigan	1.2-1.7	3.0-4.0
		Oregon	0.5-0.7	2.5-3.5
Spring release	1993	Michigan	2.4-2.6	5.7-6.2
		Oregon	0.9-1.0	4.2-4.6
Summer Steelhead:	1994	Michigan	4.0-4.2	9.7-10.2
		Irrigon Hatchery		
Summer Steelhead:	1994	Oregon	1.3-1.4	7.3-10.4
		Bonneville Hatchery		
Fall Chinook salmon: Yearlings	1993	Oregon	0.7-0.8	5.5-6.0
Spring Chinook salmon: Yearlings	1993	Oregon	0.7-0.8	4.9-6.2

Table 3. Release information for salmon and steelhead reared at Umatilla and Bonneville hatcheries and released in the Umatilla River during 19941995.

Race-species, release strategy, system	Brood year	Date released	Number released[a]	Mean fork length (mm)	Mean weight (g)	Accli-mation days	Release location
			Umatilla Hatchery				
Fall chinook salmon:							
Subyearlings	1994						
Michigan		31 May 1995	1,675,030	89.7	7.0	20	Imeques/ Thornhollow
Oregon		31 May 1995	791,268	93.2	7.5	20	Imeques
Spring chinook salmon:							
Fall release	1993						
Michigan		15 Nov 1994	236,720	148.3	47.0	17	Imeques
Oregon		15 Nov 1994	141,505	154.1	57.5	17	Imeques
Yearlings	1993						
Michigan		13 Mar 1995	90,692	155.9	52.7	21,30	Imeques
Oregon		13 Mar 1995	275,804	157.9	52.2	21,30	Imeques
Summer steelhead:	1994						
Michigan		12 May 1995	47,941	206.3	82.6	28	Bonifer
Michigan		13 Apr 1995	49,983	209.7	96.2	29	Minthorn
Michigan		11 Apr 1995	48,539	206.0	81.5	28	Bonifer
			Bonneville Hatchery				
Fall chinook salmon:							
Yearlings	1993						
Oregon		10 Apr 1995	227,088	163.7	56.7	31,32,33	Thomhollow
Spring chinook salmon:							
Yearlings:	1993						
Oregon		13 Mar 1995	74,735	149.9	35.8	18	Thornhollow
Oregon		14 Apr 1995	74,921	149.1	40.0	30	Thomhollow
Oregon		21 Apr 1995	247,871	147.9	40.8	29,30	Thomhollow

[a] ***Numbers released based on coded-wire-tag reports.***

Table 4. Egg-take of salmon and steelhead reared at Umatilla Hatchery and released during 1994-1995.

Race-species, release strategy	Egg source	Brood year	Number of eggs taken or received	Egg-to-fry survival (%)	Egg-to-smolt[a] survival (%)
Fall chinook salmon					
Subyearlings:	Priest Rapids	1994	3,877,000	67.4	63.6
Spring chinook salmon					
Fall release:	Carson	1993	1,103,000	79.9	65.0
Spring release:	Carson	1993	314,000	66.6	61.8
Summer steelhead:	Umatilla	1994	234,000	84.6	63.1

[a] ***Survival estimate is bared on green egg-to-molt stage.***

Table 5. Water quality comparisons between Michigan and Oregon systems during 1994-1995 sampling. Means are combined values for first and second pass raceways (* = significant difference between systems, NS= no significant difference, t-test, $P > 0.05$).

Race-species, parameter measured	Mean parameter value (N) Michigan	Oregon	t-test
Subyearling fall chinook salmon:			
Temperature head (“C)	12.1(14)	12.1(15)	NS
Temperature tail (“C)	12.1(14)	12.3(15)	NS
pH head	7.9(14)	8.0(15)	NS
pH tail	7.8(14)	8.0(15)	*
Oxygen head (ppm)	12.0(4)	9.6(4)	*
Oxygen tail (ppm)	9.8(4)	7.9(4)	*
Nitrogen head (mmHg)	562(4)	590(4)	*
Nitrogen tail (mmHg)	594(4)	610(4)	NS
Total pressure-head (mmHg)	732(4)	729(4)	NS
Total pressure-tail (mmHg)	734(4)	724(4)	NS
unionized ammonia (µg/l)	0.23(4)	0.25(4)	NS
Alkalinity (mg/l CaC03)	135(6)	136(6)	NS
Spring chinook salmon released in the fall:			
Temperature head (“C)	14.8(32)	15.0(32)	NS
Temperature tail (“C)	15.1(32)	15.2(32)	NS
pH head	7.9(32)	7.8(32)	NS
pH tail	7.9(32)	7.8(32)	NS
Oxygen head (ppm)	12.2(32)	10.0(32)	*
Oxygen tail @pm)	10.0(32)	9.0(32)	*
Nitrogen head (mmHg)	597(32)	625(32)	*
Nitrogen tail (mmHg)	632(32)	653(32)	*
Total pressure-head (mmHg)	785(32)	780(32)	NS
Total pressure-tail (mmHg)	789(32)	793(32)	NS
Unionized ammonia (µg/l)	0.69(16)	0.42(16)	NS
Alkalinity (mg/l CaC03)	132(16)	131(16)	NS

Table 5. Continued.

Race-species, parameter measured	Mean parameter value (N) Michigan	Oregon	t-test
Yearling spring chinook salmon:			
Temperature head (°C)	14.0(64)	14.0(58)	NS
Temperature tail (°C)	14.0(64)	14.0(58)	NS
pH head	7.9(62)	8.0(56)	NS
pH tail	7.8(62)	7.9(56)	NS
Oxygen head (ppm)	11.8(64)	10.2(58)	*
Oxygen tail (ppm)	10.2(64)	9.0(58)	*
Nitrogen head (mmHg)	589(64)	619(58)	*
Nitrogen tail (mmHg)	614(64)	640(58)	*
Total pressure-head (mmHg)	770(64)	773(58)	NS
Total pressure-tail (mmHg)	771(64)	778(58)	NS
Unionized ammonia (μg/l)	0.50(30)	0.54(27)	NS
Alkalinity (mg/l $CaCO_3$)	118(32)	122(29)	NS

Table 6. Water quality comparisons between Michigan or Oregon raceways during 1994-1995 sampling. Means are combined values for first and second pass raceways. Summer steelhead were not reared in Michigan and Oregon raceways simultaneously.

Race-species, parameter measured	Mean parameter value (N) Michigan	Oregon
Summer steelhead:		
Temperature head (“C)	12.4(43)	15.5(11)
Temperature tail (“C)	12.4(43)	15.7(11)
pH head	7.8(43)	8.0(10)
pH tail	7.7(43)	8.0(10)
Oxygen head (ppm)	13.4(40)	10.2(11)
Oxygen tail (ppm)	10.0(40)	8.8(11)
Nitrogen head (mmHg)	560(40)	649(10)
Nitrogen tail (mmHg)	595(40)	675(10)
Total pressure-head (mmHg)	752(40)	801(11)
Total pressure-tail (mmHg)	741(40)	811(11)
unionized ammonia (μg/l)	0.36(20)	0.59(5)
Alkalinity (mg/l CaC03)	112(20)	137(6)

Table 7. Water quality comparisons between first, second, and third pass Michigan raceways during 1994-1995 sampling. Means with same letter or without letters are not significantly different at P>0.05.

Race-species, parameter measured	N	Mean parameter value A pass	B pass	c pass
Subyearling fall chinook salmon:				
Temperature head (°C)	7	12.0	12.1	12.3
Temperature tail (°C)	7	12.1	12.2	12.3
pH head	7	8.0a	7.9ab	7.8b
pH tail	7	7.9	7.8	7.7
Oxygen head (ppm)	2	11.0	12.9	13.4
Oxygen tail (ppm)	2	8.7	11.0	11.0
Nitrogen head (mmHg)	2	571	552	546
Niuogen tail (mmHg)	2	608	580	583
Total pressure-head (mmHg)	2	728	737	739
Total pressure-tail (mmHg)	2	734	738	740
Unionized ammonia (μg/l)	2	0.15	0.31	0.42
Alkalinity (mg/l CaC03)	3	135	136	135
Spring chinook salmon released in the fall:				
Temperature head ("C)	16	14.8	14.9	15.4
Temperature tail ("C)	16	14.9	15.2	15.5
pH head	16	8.0	7.9	7.8
pH tail	16	7.9	7.5	7.6
Oxygen head @pm)	16	12.1	12.3	12.4
Oxygen tail (ppm)	16	9.7a	10.4ab	10.6b
Nitrogen head (mmHg)	16	598	596	592
Nitrogen tail (mmHg)	16	637	627	623
Total pressure-head (mmHg)	16	784	787	786
Total pressure-tail (mmHg)	16	788	806	790
unionized ammonia (μg/l)	8	0.54	0.85	0.93
Alkalinity (mg/l CaC03)	8	131	133	131

Table 7. Continued

Race-species, parameter measured	N	Mean parameter value A pass	B pass	c pass
Yearling spring chinook salmon:				
Temperature head (“C)	32	13.9	14.0	-
Temperature tail (“C)	32	14.0	14.0	-
pH head	31	7.9	7.9	-
pH tail	31	7.9	7.8	-
Oxygen head (ppm)	32	11.9	11.7	-
Oxygen tail @pm)	32	10.2	10.1	-
Nitrogen head (mmHg)	32	587	592	-
Nitrogen tail (mmHg)	32	614	613	-
Total pressure-head (mmHg)	32	769	771	-
Total pressure-tail (mmHg)	32	771	770	-
Unionized ammonia (μg/l)	15	0.41	0.58	-
Alkalinity (mg/l CaC03)	16	118	119	-
Summer steelhead:				
Temperature head (“C)	19	12.5	12.5	12.5
Temperature tail (“C)	19	12.6	12.5	12.5
pH head	19	7.9	7.8	7.7
pH tail	19	7.8	7.7	7.6
Oxygen head (ppm)	19	12.9	13.3	13.8
Oxygen tail @pm)	19	9.9	10.2	10.3
Nitrogen head (mmHg)	19	566	556	546
Nitrogen tail (mmHg)	19	600	589	591
Total pressure-head (mmHg)	19	756	749	745
Total pressure-tail (mmHg)	19	745	736	740
Unionized ammonia (μg/l)	9	0.31	0.44	0.48
Alkalinity (mg/l CaC03)	9	110	110	112

Table 8. Mean length, weight, and condition factor for 1994 brood subyearling fall chinook salmon reared in Michigan and Oregon raceways at Umatilla Hatchery and released in spring 1995. Letters indicate statistical groupings for tests at pre-release based on Sidak's multiple comparison test. Means with the same letter are not significantly different at P > 0.05.

Sample	System[a]	Length(mm)		Weight(g)		Condition Factor	
		N	Mean(SE)	N	Mean(SE)	N	Mean(SE)
April;	Michigan	427	73.3(0.3)	261	5.0(0.1)	261	1.29(0.01)
	Oregon	430	76.5(0.3)	247	5.4(0.1)	247	1.19(0.01)
Pre-release:							
	Michigan	1300	80.8(0.2)m	467	6.4(0.1)m	467	1.20(0.01)m
	Oregon	1224	84.8(0.2)n	426	7.0(0.1)n	426	1.15(0.01)n
Release[b]:							
	Michigan	864	89.7	447	7.0	447	0.98
	Oregon	862	93.2	447	7.5	447	0.92

[a] *First and second pass Michigan raceways*

[b] *Fish from Michigan and Oregon raceways were combined into acclimation ponds prior to release. Measurement-s at release are based on weighted means and standard errors could not be calculated.*

Table 9. Mean length, weight, and condition factor for 1994 brood subyearling fall chinook salmon reared in Michigan and Oregon passes at Umatilla Hatchery during 1995. Letters indicate statistical groupings for tests at pre-release based on Sidak's multiple comparison test. Means with the same letter are not significantly different at $P > 0.05$.

		Length(mm)		Weight(g)		ondition Factor	
Sample	Pass	N	Mean(SE)	N	Mean(SE)	N	Mean(SE)
				Michigan			
April:	A	218	73.3(0.4)	142	5.1(0.1)	142	1.29(0.01)
	B	209	73.3(0.3)	119	4.9(0.1)	119	1.22(0.01)
	C	225	75.5(0.4)	108	5.2(0.1)	108	1.22(0.01)
Pre-release:	A	681	80.5(0.3)m	259	6.3(0.1)mn	259	1.19(0.01)m
	B	619	81.1(0.3)m	208	6.6(0.1)m	208	1.20(0.01)m
	C	648	79.4(0.2)n	227	6.1(0.1)n	271	1.22(0.01)m
Release[a]:	A	453	88.9	219	7.0	447	1.00
	B	411	90.5	228	7.1	228	0.96
	c	400	88.3	211	6.9	211	0.98
				Oregon			
April:	A	220	76.5(0.4)	140	5.6(0.1)	140	1.22(0.01)
	B	210	76.5(0.4)	107	5.2(0.1)	107	1.15(0.01)
Pre-release:	A	621	84.7(0.2)m	207	6.7(0.1)m	207	1.11(0.01)m
	B	603	84.8(0.3)m	218	7.2(0.1)n	218	1.19(0.01)n
Release[a]	A	453	90.5	229	7.1	229	0.96
	B	408	93.3	228	7.6	228	0.91

[a] *Fish from Michigan and Oregon raceways were combined into acclimation ponds prior to release. Measurements at release are based on weighted means and standard errors could not be calculated.*

Table 10. Mean proportion of descaled, panially descaled, and undamaged 1994 brood subyearling fall chinook salmon reared in Michigan and Oregon raceways at Umatilla Hatchery during 1995 (SE in parentheses). Letters indicate statistical groupings for tests of descaled proportion between systems based on Wilcoxon or Kruskall-Wallis test. Means with the same letters are not significantly different at $P > 0.05$.

System	Pass	N	Descaled[a]	Partially descaled[b]	Undamaged[c]
Michigan		4[d]	0.08(0.03)m	0.61(0.06)	0.29(0.06)
	A	2	0.04(0.04)	0.52(0.00)	0.40(0.00)
	B	2	0.12(0.04)	0.70(0.08)	0.18(0.03)
	C	2	0.11(0.05)	0.45(0.03)	0.44(0.02)
Oregon		4[d]	0.00(0.00)n	0.38(0.05)	0.61(0.05)

[a] *More than 0.20 descaling on either side of the fish.*
[b] *Descaling = 0.03 to 0. 16 on either side of the fish.*
[c] *Less than 0.03 descaling on either side of the fish.*
[d] *Combined first and second pass raceways.*

Table 11. Brand and coded-wire-tag information for 1994 brood subyearling fall chinook salmon marked at Umatilla Hatchery and released in 1995 (LOC = location of brand, POS = position of brand, RA = right anterior, LA = left anterior, RV = right ventral clip, CWT = coded-wire-tag).

System	Pass	Number branded	Brand size	LOC	Brand	POS	Fin clip	Readable brands	CWT code	Number CWT[a]
Michigan	2A	10,683	3/16"	LA	L	1	RV	10,666	071019	29,353
	2B	10,447	3/16"	LA	L	3	RV	10,325	071022	28,472
	2C	10,318	3/16"	RA	L	4	RV	10,179	071025	29,784
	3A	10,366	3/16"	RA	L	1	RV	10,172	071017	29,736
	3B	10,495	3/16"	RA	L	3	RV	10,183	071020	29,460
	3c	10,311	3/16"	LA	L	4	RV	10,254	071023	28,623
Oregon	1A	10,387	3/16"	LA	E	2	RV	10,374	071026	30,106
	1B	10,278	3/16"	RA	L	2	RV	10,250	071024	30,204
	3A	10,438	3/16"	RA	E	2	RV	10,439	071018	29,132
	3B	11,124	3/16"	LA	L	2	RV	11,104	071021	29,327

[a] *Number recognizably coded-wire-tagged and released. All CWT fish are also adipose fin clipped. All fish received a right ventral fin clip and all non-CWT fish were marked with a blank-wire tag.*

Table 12. Food conversion ratios for subyearling fall chinook salmon reared in Michigan and Oregon raceways at Umatilla Hatchery, brood years 1991 - 1994.

Brood year	N	Michigan[a]	Oregon
1991	4	0.97	0.99
1992	4	1.43	1.16
1993	4	1.13	0.95
1994	4	1.30	1.30

[a] *First and second pass Michigan raceways.*

Table 13. Food conversion ratios for subyearling fall chinook salmon reared in first, second, and third pass Michigan raceways at Umatilla Hatchery, brood years 1991 - 1994.

Brood year	N	A pass	B Pass	C pass
1991	2	0.97	0.96	1.04
1992	2	1.38	1.48	1.39
1993	2	1.14	1.13	1.53
1994	2	1.37	1.17	1.42

Table 14. Pre-release mean length, weight, and condition factor for 1991-1994 brood subyearling fall chinook salmon reared in Oregon and Michigan raceways at Umatilla Hatchery (SE in parentheses, N=approximately 1200 for each mean length and 400 for each mean weight and condition factor).

System	Brood year	Length (mm)	Weight (g)	Condition factor
Michigan	1991	83.6(0.7)	7.0(0.2)	1.17(0.01)
	1992	85.6(0.2)	7.4(0.2)	1.17(0.06)
	1993	82.5(0.9)	6.8(0.2)	1.19(0.02)
	1994	80.8(0.4)	6.4(0.1)	1.20(0.02)
	1994[a]	89.7	7.0	0.98
Oregon	1991	82.5(1.5)	7.0(0.4)	1.21(0.02)
	1992	85.8(0.8)	7.5(0.2)	1.19(0.01)
	1993	85.3(1.1)	7.4(0.3)	1.18(0.04)
	1994	84.7(0.4)	7.0(0.1)	1.15(0.02)
	1994[a]	93.2	7.5	0.92

[a] *Measurements for the 1994 brood year at release after acclimation, standard errors were not available. Other brood years were not acclimated.*

Table 15. Mean length, weight, and condition factor at pre-release for 1991-1994 brood subyearling fall chinook salmon reared in first, second, and third pass Michigan raceways at Umatilla Hatchery (SE in parentheses, N = approximately 600 for each mean length and 200 for each mean weight and condition factor).

Pass	Brood year	Length (mm)	Weight (g)	Condition factor
A	1991	83.2(0.2)	7.2(0.1)	1.18(0.01)
	1992[a]	85.6(0.3)	7.5(0.1)	1.20
	1993	81.7(0.3)	6.9(0.1)	1.22(0.01)
	1994	80.5(0.3)	6.3(0.1)	1.19(0.01)
	1994[ab]	88.9	7.0	1.00
	1991	83.8(0.2)	6.9(0.1)	1.16(0.01)
	1992[a]	85.7(0.3)	7.2(0.1)	1.15
	1993	83.2(0.3)	6.7(0.1)	1.15(0.01)
	1994	81.1(0.3)	6.6(0.1)	1.20(0.01)
	1994[ab]	90.5	7.1	0.96
C	1991	83.8(0.3)	7.5(0.1)	1.20(0.01)
	1992[a]	86.5(0.3)	7.5(0.1)	1.16
	1993	82.0(0.3)	6.4(0.1)	1.11(0.01)
	1994	79.4(0.2)	6.1(0.1)	1.22(0.01)
	1994[ab]	88.3	6.9	0.98

[a] ***Standard errors for condition factor could not be calculated***

[b] ***Measurements for the 1994 brood year at release after acclimation. Other brood years were not acclimated.***

Table 16. Mean proportion of descaled, partially descaled, and undamaged subyearling fall chinook salmon reared in Michigan and Oregon raceways at Umatilla Hatchery, brood years 1991 - 1994.

Brood year	System	Descaled[a]	Partially Descaled[b]	Undamaged[c]
1991	Michigan[d]	0.03	0.36	0.62
1991	Oregon	0.04	0.61	0.35
1992	Michigan	0.04	0.62	0.35
1992	Oregon	0.01	0.74	0.26
1993	Michigan	0.12	0.54	0.34
1993	Oregon	0.00	0.12	0.88
1994	Michigan	0.08	0.06	0.29
1994	Oregon	0.00	0.39	0.61

[a] *More than 0.20 descaling on either side of the fish.*
[b] *Descaling = 0.03 to 0.16 on either side of the fish.*
[c] *Less than 0.03 descaling on either side of the fish.*
[d] *Combined first and second pass raceways.*

Table 17. Mean proportion of descaled, partially descaled, and undamaged subyearling fall chinook salmon reared in Michigan raceways at Umatilla Hatchery, brood years 1991 - 1994.

Brood year	Pass	Descaled[a]	Partially descaled[b]	Undamaged[c]
1991	A	0.04	0.33	0.64
1991	B	0.03	0.38	0.60
1991	C	0.04	0.50	0.47
1992	A	0.06	0.41	0.53
1992	B	0.01	0.82	0.17
1992	C	0.02	0.62	0.36
1993	A	0.17	0.51	0.32
1993	B	0.08	0.57	0.35
1993	C	0.04	0.60	0.36
1994	A	0.04	0.52	0.40
1994	B	0.12	0.70	0.18
1994	C	0.11	0.45	0.44

[a] *More than 0.20 descaling on either side of the fish.*
[b] *Descaling = 0.03 to 0.16 on either side of the fish.*
[c] *Less than 0.03 descaling on either side of the fish.*

Table 18. Mean survival indices for 1991-1994 brood year subyearling fall chinook salmon reared in Michigan and Oregon raceways at Umatilla Hatchery, released in the Umatilla River, and recaptured at the John Day Dam.

Brood year	N	Michigan[a]	Oregon
1991	4	2.8	1.6
1992	4	6.5	5.0
1993	4	1.5	1.7
1994	4	12.5	9.3
Mean		5.8	4.4

[a] *First and second pass Michigan raceways.*

Table 19. Mean survival indices for 1991-1994 brood year subyearling fall chinook salmon reared in first, second, and third pass Michigan raceways at Umatilla Hatchery, released in the Umatilla River, and recaptured at the John Day Dam.

Brood year	N	A pass	B pass	C Pass
1991	2	2.3	3.3	2.2
1992	2	6.0	7.0	6.9
1993	2	1.2	1.2	1.4
1994	2	10.5	14.5	11.5
Mean		5.1	6.5	5.5

Table 20. Total catch, escapement and survival of coded-wire-tagged (CWT) subyearling fall chinook salmon released in the Umatilla River, 1991-1992 brood years. Recoveries include age 2 and older fish and are incomplete for all brood years.

Brood year	System	Raceway	CWT code	N[a]	Total exploit-tation rate (%)	Umatilla return rate (% of release)	Total survival rate (% of release)
199 1	Michigan	M2A	071433	0	0.00	0.00	0.00
		M3A	071434	0	0.00	0.00	0.00
		M2B	07 1435	0	0.00	0.00	0.00
		M3B	071436	0	0.00	0.00	0.00
		M2C	07 1437	0	0.00	0.00	0.00
		M3C	071438	0	0.00	0.00	0.00
	Oregon	02A	071430	2	50.00	0.00	0.01
		03A	07 1429	0	0.00	0.00	0.00
		02B	071432	0	0.00	0.00	0.00
		03B	071431	0	0.00	0.00	0.00
1992	Michigan	M2A	076330	3	33.30	0.01	0.01
		M3A	07633 1	2	50.00	0.00	0.01
		M2B	070127	0	0.00	0.00	0.00
		M3B	076333	2	100.00	0.00	0.01
		M2C	076334	2	0.00	0.01	0.01
		M3C	076332	4	0.00	0.01	0.01
	Oregon	02A	070126	0	0.00	0.00	0.00
		03A	070125	6	67.00	0.01	0.02
		02B	076329	0	0.00	0.00	0.00
		03B	076335	2	0.00	0.01	0.01

[a] *Expanded coded-wire tag recoveries*

Table 2 1. Food conversion ratios for 1993 brood spring chinook salmon reared in Oregon and Michigan raceways and released in fall 1994. Letters indicate statistical groupings for tests between systems based on Wilcoxon or Kruskall-Wallis test. Means -with the same letters are not significantly different at $P > 0.05$.

System	Pass	N	Mean food conversion ratio (SE)
Michigan		4[a]	1.46(0.15)m
	A	2	1.56(0.17)
	B	2	1.37(0.03)
	C	2	1.38(0.13)
Oregon		4	1.14(0.17)m

[a] *Combinedjim and second pass raceways.*

Table 22. Mean length, weight, and condition factor for 1993 brood spring chinook salmon reared in Michigan and Oregon raceways at Umatilla Hatchery and released in fall 1994. Letters indicate statistical groupings for tests at pre-release based on Sidak's multiple comparison test. Means with the same letter are not significantly different at $P > 0.05$.

		Length (mm)		Weight(e)		Condition Factor	
Sample	System	N	Mean(SE)	N	Mean(SE)	N	Mean(SE)
Pre-release[a]:	Michigan	1238	138.4(0.7)m	434	37.1(0.9)m	434	1.49(0.18)m
	Oregon	1223	154.2(0.7)n	407	47.8(1.0)n	407	1.29(0.04)n
Release[b]:	Michigan	423	148.3	211	47.0	1	1.44
	Oregon	423	164.1	211	57.5	1	1.30

[a] *Prelease data collected on September 27, 1994.*
[b] *Fish were released from acclimation ponds on November 15, 1994. No standard errors were calculated from mean lengths and weights. Release condition factor was calculated from mean lengths and weights.*

Table 23. Mean length, weight, and condition factor for 1993 brood spring chinook salmon reared at Umatilla Hatchery in first, second, and third pass Michigan raceways and in first and second pass Oregon raceways. Letters indicate statistical groupings for tests at pre-release based on Sidak's multiple comparison test. Means with the same letter are not significantly different at $P > 0.05$.

		Length (mm)		Weight(g)		ondition Factor	
Sample	Pass	N	Mean(SE)	N	Mean(SE)	N	Mean(SE)
				Michigan			
July:	A	109	113.7(0.9)	88	18.6(0.4)	88	1.27(0.01)
	B	119	112.6(0.9)	54	19.3(0.6)	54	1.31(0.01)
	C	111	114.9(1.0)	50	19.2(0.7)	50	1.27(0.02)
August:	A	216	124.3(1.1)	107	27.7(1.1)	107	1.40(0.01)
	B	247	123.1(1.0)	115	28.4(1.0)	115	1.41(0.01)
	C	226	122.3(1.1)	118	27.6(0.9)	118	1.43(0.01)
September:	A	199	133.4(1.5)	104	34.9(1.6)	104	1.37(0.01)
	B	236	133.0(1.4)	109	34.0(1.5)	109	1.34(0.02)
	C	203	132.9(1.5)	123	32.1(1.4)	123	1.38(0.01)
Pre-release:	A	625	138.7(1.0)m	213	38.0(1.3)m	213	1.31(0.01)m
	B	613	138.0(0.9)m	221	36.2(1.3)m	221	1.67(0.34)m
	C	649	138.7(0.9)m	202	39.8(1.4)m	202	1.34(0.01)m
Release[a]:	A	225	138.7	103	47.8	1	1.45
	B	221	147.9	101	46.2	1	1.43
	C	208	148.6	108	49.6	1	1.51
				Oregon			
June:	A	133	101.3(0.6)	57	12.4(0.3)	57	1.19(0.01)
	B	106	102.4(0.7)	48	12.8(0.4)	48	1.20(0.02)
July:	A	97	118.8(1.0)	58	21.6(0.8)	58	1.24(0.02)
	B	107	116.7(0.9)	52	20.6(0.6)	52	1.26(0.02)

[a] *Fish from Michigan and Oregon raceways were combined into acclimation ponds prior to release. Measurements at release are bared on weighted means and standard errors could not be calculated. Condition factor at release was calculated from mean length and weight.*

Table 23. Continued

Sample	Pass	Length (mm) N	Length (mm) Mean(SE)	Weight(g) N	Weight(g) Mean(SE)	ondition Factor N	ondition Factor Mean(SE)
August:	A	214	128.2(1.1)	102	20.6(1.1)	102	1.33(0.01)
	B	229	128.3(1.0)	111	27.9(0.8)	111	1.32(0.01)
September:	A	210	152.1(1.4)	109	45.6(1.6)	109	1.28(0.01)
	B	205	148.3(1.3)	107	43.2(1.4)	107	1.30(0.01)
Pre-release:	A	620	157.1(1.1)m	206	51.2(1.5)m	206	1.32(0.1)m
	B	603	151.2(1.0)n	201	44.3(1.3)n	201	1.25(0.1)m
Release[a]:	A	208	167.1	108	61.0	1	1.31
	B	104	161.1	53	54.1	1	1.29

Table 24. Mean proportion of descaled, partially descaled, and undamaged 1993 brood spring chinook salmon reared in Michigan and Oregon raceways at Umatilla Hatchery and released in fall 1994 (SE in parentheses).

System	Pass	N	Descaled[a]	Partially descaled[b]	Undamaged[c]
Michigan		4[d]	0.37(0.05)	0.36(0.11)	0.27(0.09)
	A	2	0.44(0.05)	0.20(0.14)	0.36(0.19)
	B	2	0.30(0.02)	0.53(0.08)	0.18(0.01)
	C	2	0.30(0.09)	0.49(0.03)	0.20(0.06)
Oregon		4[d]	0.21(0.08)	0.45(0.03)	0.37(0.11)

[a] *More than 0.20 descaling on either side of the fish.*
[b] *Descaling = 0.03 to 0.16 on either side of the fish.*
[c] *Less than 0.03 descaling on either side of the fish.*
[d] *Combined first and second pass raceways.*

Table 25. Brand and coded-wire-tag information for 1993 brood spring chinook salmon marked at Umatilla Hatchery and released in fall 1994 (AD = adipose, RV = right ventral clip, CWT = coded-wire-tag).

System	Raceway	Fin clip	CWT code	Number CWT[a]
Michigan	M2A	ADRV	070728	34,808
	M2B	ADRV	070726	35,156
	M2C	ADRV	070724	34,124
	M3A	ADRV	070729	35,160
	M3B	ADRV	070727	34,819
	M3C	ADRV	070725	34,827
Oregon	O1A	ADRV	07073 1	35,750
	O1B	ADRV	070733	34,220
	02A	ADRV	070730	34,915
	02B	ADRV	070732	32,251

[a] ***Number recognizably coded-wire-tagged and released. All CWT fish are also adipose fin clipped. All fish received a right ventral fin clip and all non-CWT fish were marked with a blank-wire tag.***

Table 26. Mean length, weight, and condition factor for 1994 brood summer steelhead reared in Michigan raceways at Umatilla Hatchery and for Imnaha and Wallowa stock summer steelhead reared in Oregon raceways at Irrigon Hatchery during 1994-1995.

Sample period	Pass	Length(mm) N	Length(mm) Mean(SE)	Weight(g) N	Weight(g) Mean(SE)	'ondition factor N	'ondition factor Mean(SE)
			Umatilla Hatchery				
September:	A	102	77.8(1.1)	53	5.8(0.4)	53	1.20(0.01)
October:	A	115	94.0(1.0)	115	9.6(0.3)	115	1.12(0.01)
	B	124	81.8(0.8)	68	12.0(0.4)	68	1.10(0.01)
	C	101	111.7(0.9)	53	17.9(2.1)	53	1.30(0.16)
November:	A	124	108.6(1.1)	55	15.6(0.7)	55	1.18(0.01)
	B	102	123.4(1.1)	52	28.2(4.1)	52	1.41(0.22)
	C	111	132.3(1.1)	50	28.4(1.0)	50	1.20(0.01)
December:	A	107	133.3(1.3)	67	30.9(1.1)	67	1.23(0.01)
	B	98	143.9(1.4)	52	36.7(1.4)	52	1.28(0.04)
	C	103	149.7(1.2)	52	39.9(1.3)	52	1.16(0.01)
January:	A	99	154.7(1.8)	55	47.7(2.0)	55	1.20(0.01)
	B	112	170.2(1.1)	51	58.5(1.8)	51	1.18(0.01)
	C	103	177.2(1.3)	60	65.7(2.1)	60	1.17(0.01)
February:	A	105	170.8(1.9)	60	63.2(2.7)	60	1.19(0.01)
	B	102	189.9(1.7)	65	81.5(3.0)	65	1.17(0.01)
	C	110	194.0(1.5)	55	83.6(3.2)	55	1.14(0.01)
March:	A	107	184.0(2.0)	51	74.8(3.5)	51	1.14(0.01)
Pre-Release:	A[a]	315	206.3(1.1)	128	82.6(2.2)	128	0.90(0.01)
	B[b]	300	209.7(1.0)	101	96.2(2.7)	101	1.00(0.01)
	C[b]	316	205.9(0.8)	117	81.4(1.8)	117	0.90(0.01)

[a] *Steelhead from the 1st pass raceway were transferred to an acclimation pond on April 17 and released into the Umatilla River on May 12 1995*

[b] *Steelhead from 2nd and 3rd pass raceways were transferred to acclimation ponds on March I 4-15 and released inro the Umatilla River on April 13 and II 1995, respectively*

[c] *Data presented for 1st and 2ndpass Irrigon steelhead are Imnaha and Wallowa stock. respectively.*

Table 26. Continued.

Sample period	Pass	Length(mm) N	Length(mm) Mean(SE)	Weight(g) N	Weight(g) Mean(SE)	Condition factor N	Condition factor Mean(SE)
				Irrigon Hatchery			
Pre-Release[c]:	A	214	201.0(20.4)	61	87.3(26.4)	61	1.07(0.08)
	B	210	206.0(18.6)	100	101.7(39.3)	100	1.11(0.12)

Table 27. **Dry** food conversion **ratios**[a] for summer **steelhead** reared in Michigan raceways at Umatilla Hatchery and in Oregon raceways at Irrigon Hatchery during 1994-1995.

Svstem	Stock	Pass	Mean food conversion ratio
	Umatilla Hatchery		
Michigan[b]			0.93
	Umatilla	A	0.92
	Umatilla	B	0.93
	Umatilla	C	0.99
	Irrigon Hatchery		
Oregon[b]			1.03
	Imnaha	A	1.10
	Wallowa	B	0.95

a *Dry food conversion ratio is determined by (pounds of feed - (pounds of feed * % moisture))/pounds of fish.*

b *Combined 1st and 2nd pass raceways.*

Table 28. Proportion of descaled, partially descaled, and undamaged 1994 brood summer steelhead reared in first, second, and third pass Michigan raceways at Umatilla Hatchery during 1994-1995.

System	Pass	N	Descaled[a]	Partially descaled[b]	Undamaged[c]
Michigan:					
	A	195	0.13	0.39	0.48
	B	199	0.00	0.21	0.79
	C	195	0.09	0.42	0.50

[a] *More than 0.20 descaling on either side of the fish.*
[b] *Descaling* = 0.03 to 0.16 *on either side of the fish.*
[c] *Less than 0.03 descaling on either side of the fish.*

Table 29. Severity of fin erosion[a] among 1994 brood summer steelhead reared in Michigan raceways at Umatilla Hatchery in 19941995.

	Percent severity of fin erosion								
	Light			Moderate			Severe		
Fin	A pass	B pass	C Pass	A Pass	B Pass	C pass	A Pass	B pass	C pass
Dorsal	4.2	53.5	63.3	77.1	38.6	30.1	18.8	7.9	6.6
Caudal	81.3	99.5	98.0	16.7	0.5	1.5	2.1	0.0	0.5
Pectoral	77.6	94.1	89.8	12.5	4.0	8.2	9.9	2.0	2.0

[a] *Light erosion = more than 90% of fin remaining, little or no damage.*
Moderate erosion = fin approximately 50% eroded.
Severe erosion = less than 25% ofjin remaining, almost no fin rays visible.

Table 30. Brand and coded-wire tag information for 1994 brood summer steelhead marked at Umatilla Hatchery in 1994-1995 (LOC = location of brand, RA = right anterior, POS = position of brand. AD = adipose, CWT = coded-wire tag.)

System	Pass	Number branded	Brand Size	LOC	Brand	POS	Fin clip	Readable brands	CWT code	Number CWT[a]
Michigan:	A	10,144	1/4"	RA	B	4	AD	8,908	070655	19,782
	B	10,353	1/4"	RA	B	1	AD	8,134	070656	18,812
	C	10,250	1/4"	RA	B	2	AD	7,771	070657	19,290

[a] *Number recognizably coded-wire-tagged and left ventral fin clip.*

Table 31. Total catch, escapement and survival of coded-wire-tagged Umatilla stock summer steelhead released in the Umatilla River, 1991-1992 brood years.

Brood year	System	Raceway	CWT code	N[a]	Total exploit-tation rate(%)	Umatilla return rate (% of release)	Total survival rate (% of release)
1991	Michigan	M5A	075838	1	0.00	0.01	0.01
		M5A	075839	0	---	0.00	0.00
		M5A	075840	3	0.00	0.03	0.03
		M5B	075841	2	100.00	0.00	0.02
		M5B	075842	0	---	0.00	0.00
		M5B	075843	4	100.00	0.00	0.04
		M5C	074127	22	0.00	0.22	0.22
		M5C	073862	22	27.30	0.15	0.21
		M5C	073759	21	57.10	0.09	0.20
1992	Michigan	M5A	076052	3	---	0.02	0.02
		M5A	076053	0	---	0.00	0.00
		M5A	076054	3	---	0.03	0.03
		M5B	076055	26	---	0.26	0.26
		M5B	076056	20	---	0.21	0.21
		M5B	076057	26	---	0.27	0.27
		M5C	076058	29	---	0.28	0.28
		M5C	076059	23		0.23	0.23
		M5C	076060	49	---	0.52	0.52

[a] *Expanded rag recoveries.*

Table 32. Mean length, weight, and condition factor for 1993 brood spring chinook salmon reared in Michigan and Oregon system raceways at Umatilla Hatchery during 1994-1995. Letters indicate statistical groupings for tests at pre-release based on Sidak's- multiple comparison test. Means with the same letter are not significantly different at $P>0.05$.

		Length(mm)		Weight(g)		Condition Factor	
Sample	System	N	Mean(SE)	N	Mean(SE)	N	Mean(SE)
June:	Oregon	229	84.2(0.7)	112	7.4(0.3)	112	1.22(0.01)
July:	Michigan	237	103.5(0.6)	130	13.9(0.3)	130	1.26(0.01)
	Oregon	105	85.6(0.6)	68	7.9(0.2)	68	1.21(0.01)
August:	Michigan	213	115.6(0.9)	166	19.0(0.5)	166	1.20(0.01)
	Oregon	414	92.8(0.3)	257	10.6(0.1)	257	1.30(0.01)
September:	Michigan	219	121.7(1.2)	107	23.6(1.0)	107	1.32(0.02)
	Oregon	419	112.4(0.3)	251	19.9(0.2)	251	1.37(0.01)
October:	Michigan	208	122.5(1.3)	118	25.7(1.2)	118	1.34(0.01)
	Oregon	429	126.0(0.4)	226	28.3(0.5)	226	1.39(0.01)
November:	Michigan	219	134.4(1.4)	108	31.8(1.6)	108	1.34(0.01)
	Oregon	410	134.4(0.5)	201	33.0(0.6)	201	1.33(0.01)
December:	Michigan	211	139.0(1.6)	106	39.3(2.3)	106	1.32(0.01)
	Oregon	414	146.4(0.6)	230	43.6(0.8)	230	1.37(0.01)
January:	Michigan	214	151.1(1.8)	114	44.4(2.2)	114	1.28(0.01)
	Oregon	420	156.6(0.8)	220	52.0(1.1)	220	1.32(0.01)
Pre-release[a]:	Michigan	603	155.9(1.2) m	223	52.7(2.2)m	223	1.30(0.02)m
	Oregon	1235	159.1(0.4) n	427	51.9(0.8)m	427	1.24(0.01)n
Release[b]:	Michigan	60	166.9	60	57.8	60	1.24
	Oregon	60	171.0	60	56.9	60	1.16

[a] *Pre-release data was collected on 7 and 8 February 199.5.*
[b] *Fish were released from acclimation ponds on 13 March 1995. No standard errors were calculated on weighted means.*

Table 33. Mean length, weight, and condition factor for 1993 brood spring chinook salmon reared in Oregon system raceways at Umatilla Hatchery during 1994-1995.

		Length (mm)		Weight(g)		ondition Factor	
Sample	Pass	N	Mean(SE)	N	Mean(SE)	N	Mean(SE)
June :	A	229	84.2(0.7)	112	7.4(0.3)	112	1.22(0.01)
July:	A	105	85.6(0.6)	68	7.9(0.2)	68	1.21(0.01)
August:	A	207	93.4(0.4)	129	10.7(0.2)	129	1.30(0.01)
	B	207	92.2(0.4)	128	10.4(0.2)	128	1.30(0.01)
September:	A	215	112.5(0.5)	138	19.7(0.3)	138	1.36(0.01)
	B	204	112.3(0.5)	113	20.1(0.4)	113	1.39(0.01)
October:	A	207	125.7(0.7)	117	28.3(0.7)	117	1.41(0.01)
	B	222	126.3(0.5)	109	28.4(0.6)	109	1.37(0.01)
November:	A	207	134.3(0.7)	101	33.1(0.8)	101	1.33(0.01)
	B	203	134.6(0.7)	100	32.8(0.8)	100	1.33(0.01)
December:	A	205	145.7(0.9)	119	42.1(0.9)	119	1.33(0.01)
	B	209	147.2(0.9)	111	45.3(0.9)	111	1.41(0.01)
January:	A	217	156.3(1.2)	109	51.5(1.6)	109	1.29(0.01)
	B	203	156.9(1.1)	111	52.5(1.5)	111	1.36(0.01)
Pre-release[a]:	A	633	159.2(0.6)	225	51.0(1.1)	225	1.23(0.01)
	B	602	159.1(0.6)	202	52.9(1.1)	202	1.26(0.01)
Release[b]:	A	60	170.2	60	56.0	60	1.14
	B	60	170.1	60	57.8	60	1.18

[a] *Pre-release data collected on 7 and 8 February 1995.*
[b] *Fish were released from acclimation ponds on 13 March 1995. No standard errors were calculated on weighted means.*

Table 34. Mean length, weight, and condition factor for 1993 brood spring chinook salmon reared in Michigan system raceways at Umatilla Hatchery during 1994-1995.

		Length(mm)		Weight(g)		Condition Factor	
Sample	Pass	N	Mean(SE)	N	Mean(SE)	N	Mean(SE)
July:	A	118	102.8(1.0)	80	13.7(0.4)	80	1.26(0.01)
	B	119	104.1(0.8)	50	14.3(0.5)	50	1.26(0.02)
August:	A	104	116.1(1.2)	104	19.1(0.6)	104	1.19(0.01)
	B	109	115.1(1.3)	62	18.7(0.7)	62	1.21(0.01)
September:	A	108	119.3(1.6)	55	22.4(1.1)	55	1.36(0.03)
	B	111	124.1(1.8)	52	24.8(1.6)	52	1.28(0.01)
October:	A	104	122.2(1.8)	63	22.5(1.1)	63	1.32(0.01)
	B	104	122.9(1.9)	55	29.4(2.1)	55	1.36(0.02)
November :	A	112	133.2(1.9)	56	31.6(1.9)	56	1.36(0.01)
	B	107	133.6(2.2)	52	32.1(2.5)	52	1.31(0.02)
December:	A	103	140.7(2.2)	54	40.1(3.0)	54	1.31(0.01)
	B	108	137.3(2.3)	52	38.6(3.4)	52	1.32(0.02)
January:	A	104	146.9(1.9)	58	40.6(1.8)	58	1.28(0.01)
	B	100	155.5(3.0)	56	48.2(3.9)	56	1.39(0.01)
Pre-release[a]:	A	301	156.1(1.8)	109	54.5(3.2)	109	1.29(0.01)
	B	302	155.7(1.7)	114	51.0(3.1)	114	1.30(0.03)
Release[b]:	A	60	167.1	60	59.5	60	1.27
	B	60	166.7	60	56.0	60	1.21

[a] *Pre-release data was collected on 7 and 8 February 1995.*

[b] *Fish were released from acclimation ponds on 13 March 1995. No standard errors were calculated on weighted means.*

Table 35. Mean length, weight, and condition factor for 1993 brood spring chinook salmon reared in Oregon raceways at Bonneville Hatchery during 19941995.

Sample	Raceway	Length (mm)		Weight(g)		Condition Factor	
		N	Mean(SE)	N	Mean(SE)	N	Mean(SE)
Pre-release:	B5[a]	302		104		104	
	B6[b]		133.9(137.8(0.8)		131.0(1.30.8(2)	112	1.22(0.01)
	B7[c]	315	140.5(1.0)	106	33.9(1.2)	106	1.21(0.01)
	B8[c]	323	138.7(0.9)	77	34.6(2.0)	77	1.18(0.01)
Release:	B5	60	144.9	60	35.8	60	1.18
	B6-B8		148.2		40.6		1.25

[a] *Pre-release data was collected on February 15. 1995.*
[b] *Pre-release data was collected on March 15, 1995.*
[c] *Pre-release data was collected on March 22, 1995.*

Table 36. Proportion of descaled, partially descaled, and undamaged 1993 brood yearling spring chinook salmon reared in Oregon and Michigan raceways at Umatilla Hatchery and in Oregon raceways at Bonneville Hatchery during 1994-1995.

System	Pass	N	Descaled[a]	Partially descaled[b]	Undamaged[c]
			Umatilla Hatchery		
Michigan[d]		2	0.03	0.24	0.74
	A	1	0.05	0.38	0.57
	B	1	0.00	0.09	0.91
Oregon		4	0.00	0.15	0.85
	A	2	0.01	0.19	0.81
	B	2	0.00	0.11	0.89
			Bonneville Hatchery		
Oregon[e]		4	0.00	0.04	0.96

[a] *More than 0.20 descaling on either side of the fish.*
[b] *Descaling = 0.03 to 0.16 on either side of the fish.*
[c] *Less than 0.03 descaling on either side of the fish.*
[d] *Combined first and second pass raceways.*
[e] *First pass raceways.*

Table 37. Brand and coded-wire-tag information for 1993 brood spring chinook salmon yearlings marked at Umatilla and Bonneville hatcheries and released in 1995 (LOC = location of brand, POS = position of brand, LA = left anterior, RA = right anterior, RV = right ventral clip, CWT = coded-wire-tag).

System	Pass	Number branded	Brand Size	LOC	Brand	POS	Fin clip	Readable brands	CWT code	Number CWT[a]
				Umatilla Hatchery						
Michigan	5A	5,102	3/16"	RA	B	1	RV	4,910	07 1453	20,315
	5B	5,510	3/16"	RA	B	4	RV	4,436	071454	15,561
Oregon	4A	5,291	3/16"	LA	B	1	RV	5,176	07065 1	18,864
	4B	5,293	3/16"	LA	B	3	RV	4,975	070652	19,052
	5A	5,208	3/16"	LA	B	2	RV	5,063	070654	19,091
	5B	5,271	3/16"	LA	B	4	RV	5,133	070653	18,175
				Bonneville Hatchery						
Oregon	B5						RV		070660	23,607
	B6						RV		070661	28,765
	B7	5,296	3/16"	RA	B	3	RV	5,137	070649	22,189
	B8	5,082	3/16"	RA	B	2	RV	4,878	070650	24,088

[a] ***Number recognizably coded-wire-tagged and released. Ail CWT fish were adipose fin clipped.***

Table 38. Total catch, escapement and survival of coded-wire-tagged (CWT) fall chinook yearlings reared at Bonneville Hatchery and released in the Umatilla River, 1990-1992 brood years. Recoveries include age 2 and older fish and are incomplete for all brood years.

Brood year	System	Raceway	CWT code	N[a]	Total exploit-tation rate(%)	Umatilla return rate (% of release)	Total survival rate (% of release)
1990	Oregon	A8	075618	5	100.00	0.00	0.02
		A9	075619	1	0.00	0.00	0.00
1991	Oregon	A5	071460	4[b]	0.00	0.02	0.02
		A6	071461	12[c]	42.00	0.03	0.05
1992	Oregon	A5	070252	15[d]	0.00	0.06	0.06
		A6	070255	32[d]	3.00	0.13	0.14

[a] *Expanded coded-wire rag recoveries*
[b] *Three of four recoveries were age two subjacks (<* 15' *FL)*
[c] *Three of 12 recoveries were age two subjacks (<* 15" FL)
[d] *All recoveries were age two subjacks (< 15" FL)*

Table 39. Number of subyearling and yearling fall chinook salmon planned for release in the Umatilla River and predicted escapement of returning adults above Lower Granite Dam. Estimates are based on 95 % confidence intervals of mean survival rates and on minimum and maximum survival rates observed for coded-wire tag recoveries for the 1983 to 1989 brood years.

1995 Release Year

		Escapement above Lower Granite Dam					
		95% CI			Min/Max		
Group	Number	Low	Mean	High	Low	Mean	High
Subyearlings	2,682,000	2	24	74	0	24	96
Yearlings	225,000	0	2	8	0	2	10
Total	2907,000	2	26	82	0	26	106

1996 Release Year

		Escapement above J ower Granite					
		95% CI			Min/Max		
Group	Number	Low	Mean	High	Low	Mean	High
Subyearlings	2,682,000	2	24	74	0	24	96
Yearlings	600,000	0	7	21	0	7	25
Total	3,285,000	2	31	95	0	26	121

Table 40. Recovery of marked adult fall chinook salmon returning to Three Mile Falls Dam in the Umatilla River from 1992 to 1994. Marking evaluation was initiated in 1991 at Irrigon Hatchery and continued in 1992 and 1993 at Umatilla Hatchery.

Brood year[a]	Mark	Number released	CWT Code	Three Mile Falls Dam Returns 1992	1993	1994	Total	Survival (%)
1990	BT	147,586		-	2	13	15	0.010
	AD+CWT	51,814	75450	1	2	17	20	0.039
		52,444	7545 1	2	3	7	12	0.023
	AD+CWT+RV	52,252	75225	0	1	12	13	0.025
		51,728	75226	0	2	3	5	0.010
	AD+CWT+BT	48,266	75328	3	3	7	13	0.027
		48,481	75499	2	1	12	15	0.03 1
		48,301	70016	0	1	6	7	0.014
1991	LV	69,816		-	1	4	5	0.003
		74,408		-				
	BT+LV	67,144		-	0	0	0	0.000
		65,749		-				
	BT	65,184		-	2	5	7	0.011
		70,435		-				
	AD+CWT+RV	32,278	71430	-	0	0	0	0.000
		31,892	71429	-	0	1	1	0.003
1992	LV	61,801		-		12	12	0.009
		66,204		-				
	BT+LV	68,644		-		7	7	0.010
		70,442		-				
	BT	69,225		-		7	7	0.010
		69,518		-				
	AD+CWT+RV	29,594	70126	-		0	0	0.000
		29,360	70125	-		2	2	0.007

[a] Fish not coded-wire tagged were assigned to a brood year by length frequency data.

Table 41. Estimated catch statistics for fall chinook salmon and coho salmon in the lower Umatilla River from Hwy 730 to Three Mile Falls Dam for the 1994 fall chinook/coho creel season[a]. Number caught and number harvested included ± 95% confidence interval.

Month, Day type	Number Sampled days	Number Sampled anglers	Hrs fished	Fall Chinook Salmon Number caught	Fall Chinook Salmon Number harvested	Fall Chinook Salmon Catch rate fish/h	Coho Salmon Number caught	Coho Salmon Number harvested	Coho Salmon Catch rate (fish/h)
September									
Weekday	8	20	275	9±31	0± 0	0.033	0± 0	0± 0	0.000
Weekend	8	67	239	3±2	1± 2	0.013	5± 3	5± 3	0.021
Total	16	87	514	12±3	31± 2	0.023	5± 3	5± 3	0.010
October									
Weekday	13	105	587	23±16	14±12	0.039	23±17	12±12	0.039
Weekend	10	176	703	64±30	29±16	0.091	20± 7	8± 6	0.028
Total	23	281	1290	87±34	43±20	0.067	43±18	20±13	0.033
November									
Weekday	11	68	524	85±69	17±19	0.162	14±13	4± 7	0.027
Weekend	9	160	570	66±24	12± 9	0.116	13±12	4± 5	0.023
Total	20	228	1094	151±73	29±21	0.138	27±17	8± 9	0.025
Season									
Total	59	5%	2898	250±86	73±29	0.086	75±25	33±16	0.026

[a] *Steelhead could be harvested below the highway 730 bridge and were included in the survey. We estimated that 13 ± 4 steelhead were caught and 10±2 were harvested in this section of the Umatilla.*

Table 42. Estimated catch statistics for 1994-95 summer steelhead creel. Lower river = Mouth of the Umatilla River to Three Mile Falls Dam. Upper River = Stanfield Dam to the lower boundary of the Confederated Tribes of the Umatilla Indian Reservation boundary. Number caught and number harvested includes ± 95% confidence interval.

Month	Number sampled		Hours	Number	Number	Catch rate
Day type	days	anglers	fished	caught	harvested	(fish/hr)
			Lower River			
September						
Weekday	8	20	275	4± 6	0± 0	0.015
Weekend	8	67	239	o+ 0	o+ 0	0.000
Total	16	87	514	4± 6	Of 0	0.008
October						
Weekday	13	105	587	17+15	6±8	0.029
Weekend	10	176	703	8±12	6±9	0.011
Total	23	281	1290	25±19	12±12	0.019
November						
Weekday	11	68	524	31±25	12±13	0.059
Weekend	9	160	570	9± 4	4±4	0.016
Total	20	228	1094	40±26	16±14	0.037
December						
Weekday	9	42	194	31±21	0±0	0.160
Weekend	6	75	393	56±32	8±9	0.142
Total	15	117	587	87±38	8±9	0.148
January						
Weekday	5	6	44	Of 0	0±0	0.000
Weekend	4	19	142	17±22	4±7	0.120
Total	9	25	186	17±22	4±7	0.091
February						
Weekday	2	1	9	Of 0	0±0	0.000
Weekend	2	10	28	0± 0	0±0	0.000
Total	3	11	37	0± 0	0±0	0.000
March						
Weekday	5	8	71	6±12	0±0	0.085
Weekend	2	24	180	Of 0	0±0	0.000
Total	7	32	251	6±12	0±0	0.000

Table 42. Continued.

April						
Weekday	2	2	39	**0**± 0	**0±0**	0.000
Weekend	1	0	0	**0**± 0	**0±0**	0.000
Total	3	2	39	O f 0	**0±0**	0.000
Grand Total	97	783	3998	**179±56**	**40±21**	0.045

Month **Day type**	Number sampled days	 anglers	Hours fished	Number caught	Number harvested	Catch **rate** **(fish/hr)**
			Upper River			
December						
Weekday	1	0	0	**0±0**	**0±0**	0.000
Weekend	2	22	276	**7±14**	**0±0**	0.025
Total	3	22	276	**7±14**	**0±0**	0.025
January						
Weekday	4	20	291	**0±0**	**0±0**	0.000
Weekend	4	29	150	**0±0**	**0±0**	0.000
Total	8	49	441	**0±0**	**0±0**	0.000
February						
Weekday	5	25	200	**26±33**	**6±11**	0.125
Weekend	4	28	83	**2±6**	**0±0**	0.024
Total	9	53	283	**27±33**	**6±11**	0.095
March						
Weekday	6	27	289	**12±21**	**12±21**	0.042
Weekend	5	74	333	**5±4**	**0±0**	0.015
Total	11	101	622	**17±22**	**12±21**	0.027
April						
Weekday	2	14	342	**0±0**	**0±0**	0.000
Weekend	4	48	210	**27±23**	**3±6**	0.129
Total	6	62	552	**27±23**	**3±6**	0.049
Grand Total	37	287	2174	. **78±48**	**21±24**	0.036

Table 43. Residence of anglers for the 1994 fall chinook and coho salmon creel survey and the 1994-95 summer steelhead creel survey (chf = fall chinook salmon).

River	Survey	Number of anglers interviewed	Angler residence (%)		
			Umatilla and Morrow Counties	Other Oregon counties	out of state
Umatilla	coho/ fall chinook	640	94.2	4.1	1.7
Lower Umatilla	summer steelhead	374	92.3	4.8	2.9
Upper Umatilla	summer steelhead	203	92.1	7.4	0.5

Table 44. Coded-wire-tagged recoveries for the 1994 fall chinook and coho salmon and the 1994-1995 summer steelhead creel survey on the Umatilla River.

Fishery	Tag code	Number recovered	
		Observed	Expanded
coho	071523	2	4
fall chinook	075328	1	1
	070255	2	3
	634912	1	2
	634918	1	2
	634920	1	1
	635229	1	2
summer steelhead	073759	1	1
	076056	1	2
	076057	1[a]	1
	076058		
	076059	1	2
	076060	1	1

[a] *No expansion, voluntary angler return.*

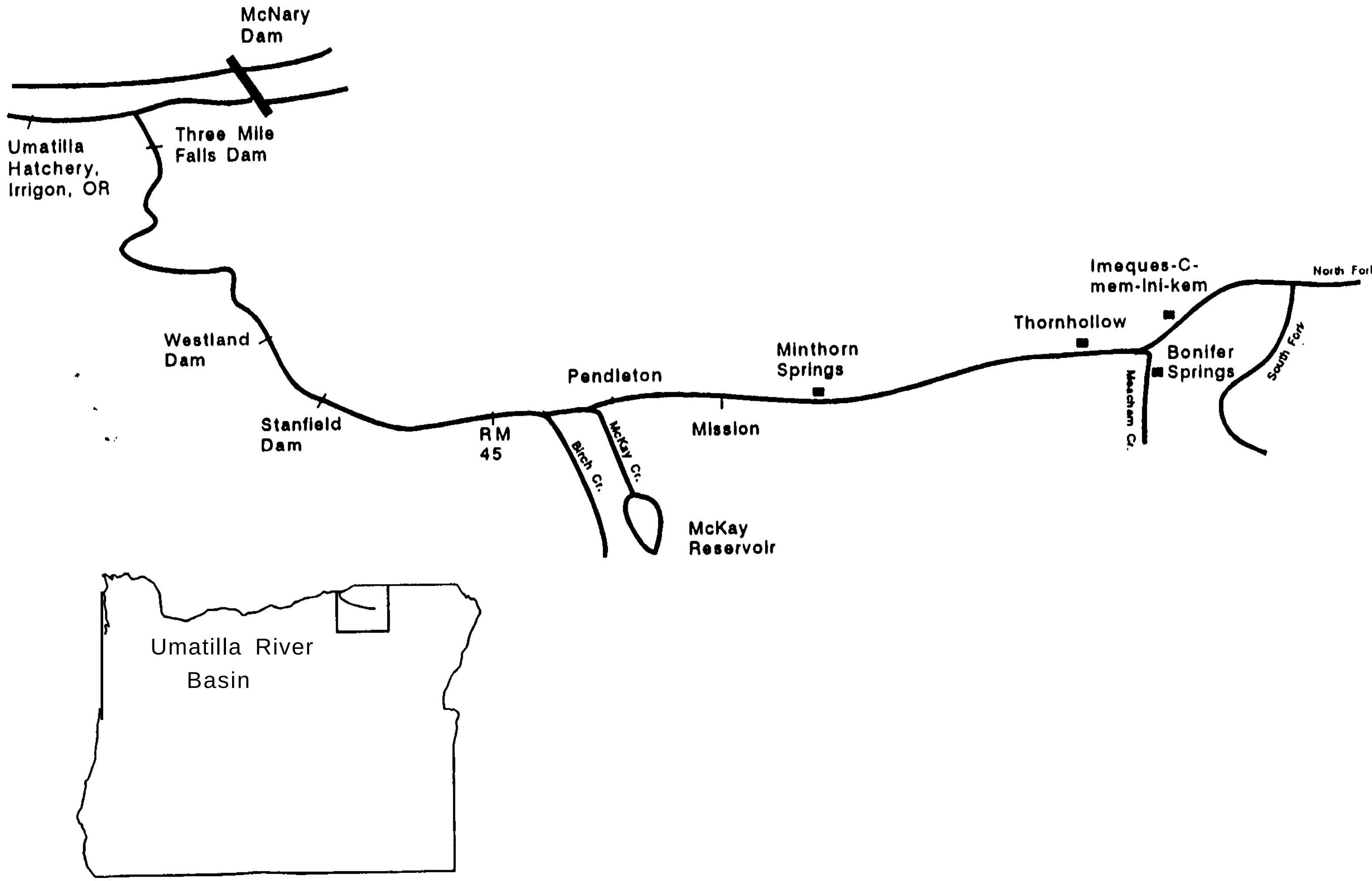


Figure 1 Location map, Umatilla Basin

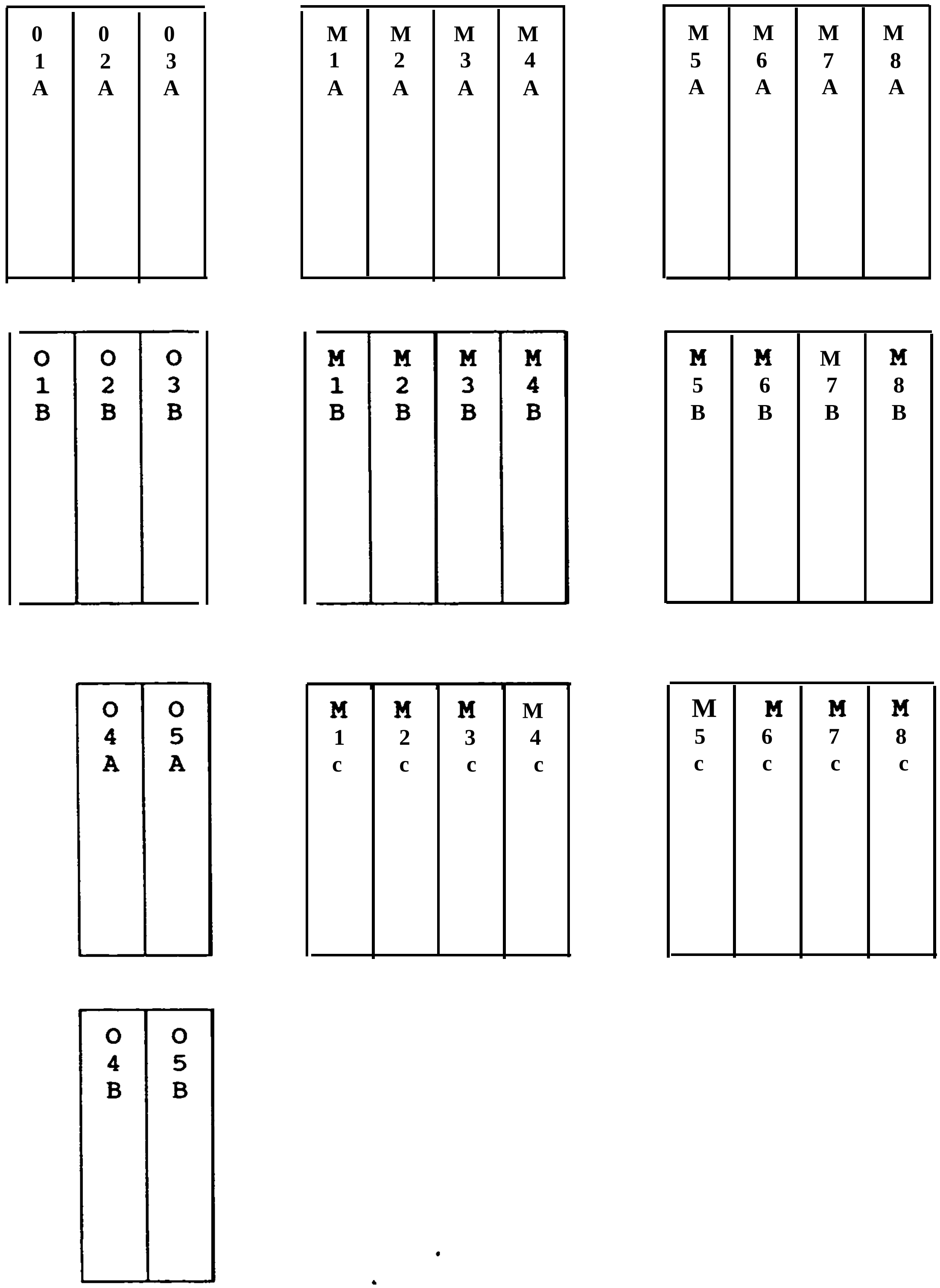


Figure 2. Raceway schematic for Umatilla Hatchery (0 = Oregon raceway, M = Michigan raceway, number = raceway, A = first pass, B = second pass, C = third pass).

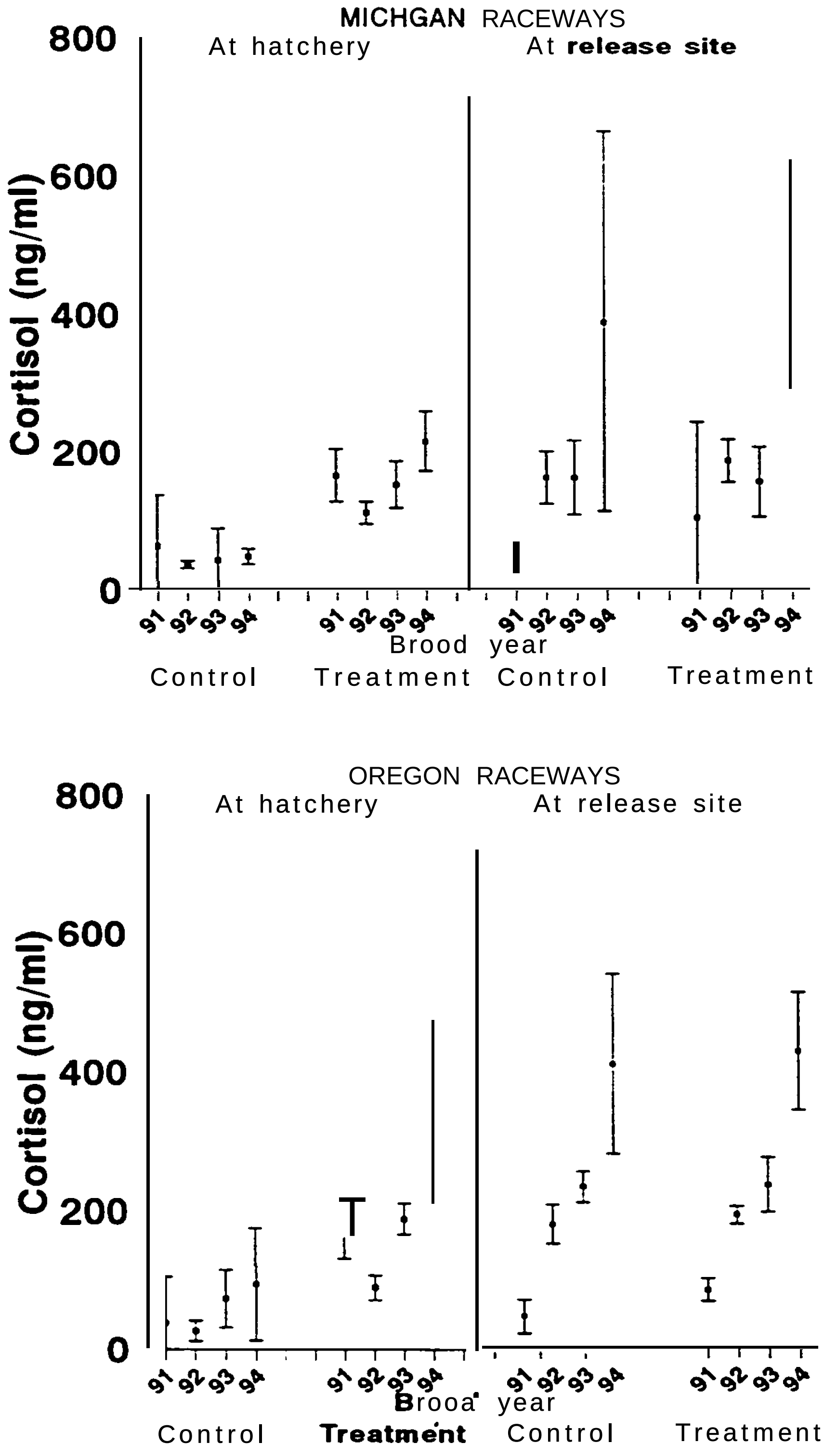


Figure 3. Mean plasma cortisol concentration from subyearling fall chinook salmon reared in Michigan and Oregon raceways at Umatilla Hatchery (1991-1994 brood years). Fish were tested at the hatchery and after transportation to the release site. Treatment fish were held out of water for 30 seconds. (N = 18 for each mean, bars = 95% confidence intervals).

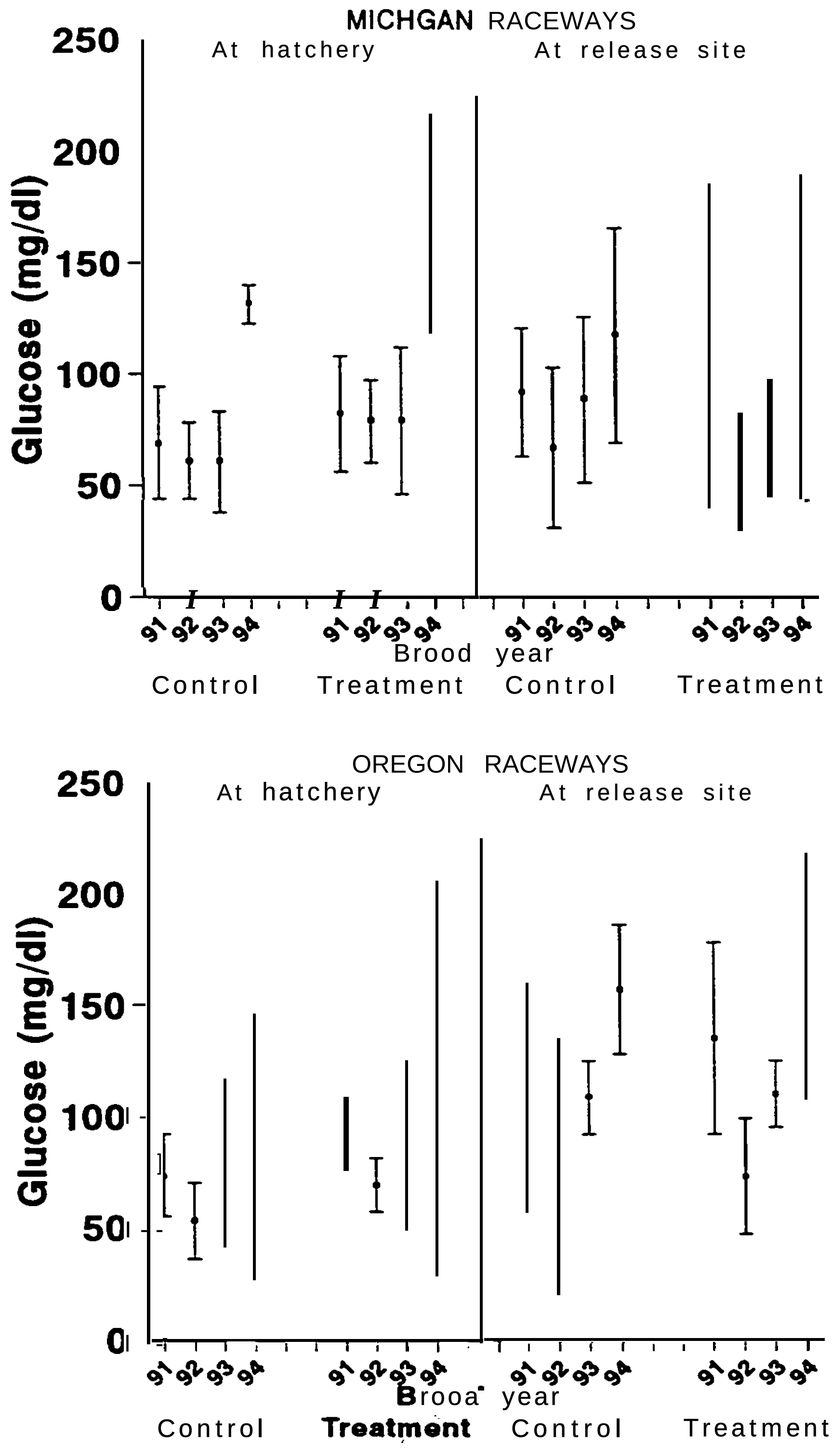


Figure 4. Mean plasma glucose concentration from subyearling fall chinook salmon reared in Michigan and Oregon raceways at Umatilla Hatchery (1991-1994 brood years). Fish were tested at the hatchery and after transportation to the release site. Treatment fish were held out of water for 30 seconds. (N = 18 for each mean, bars = 95% confidence intervals).

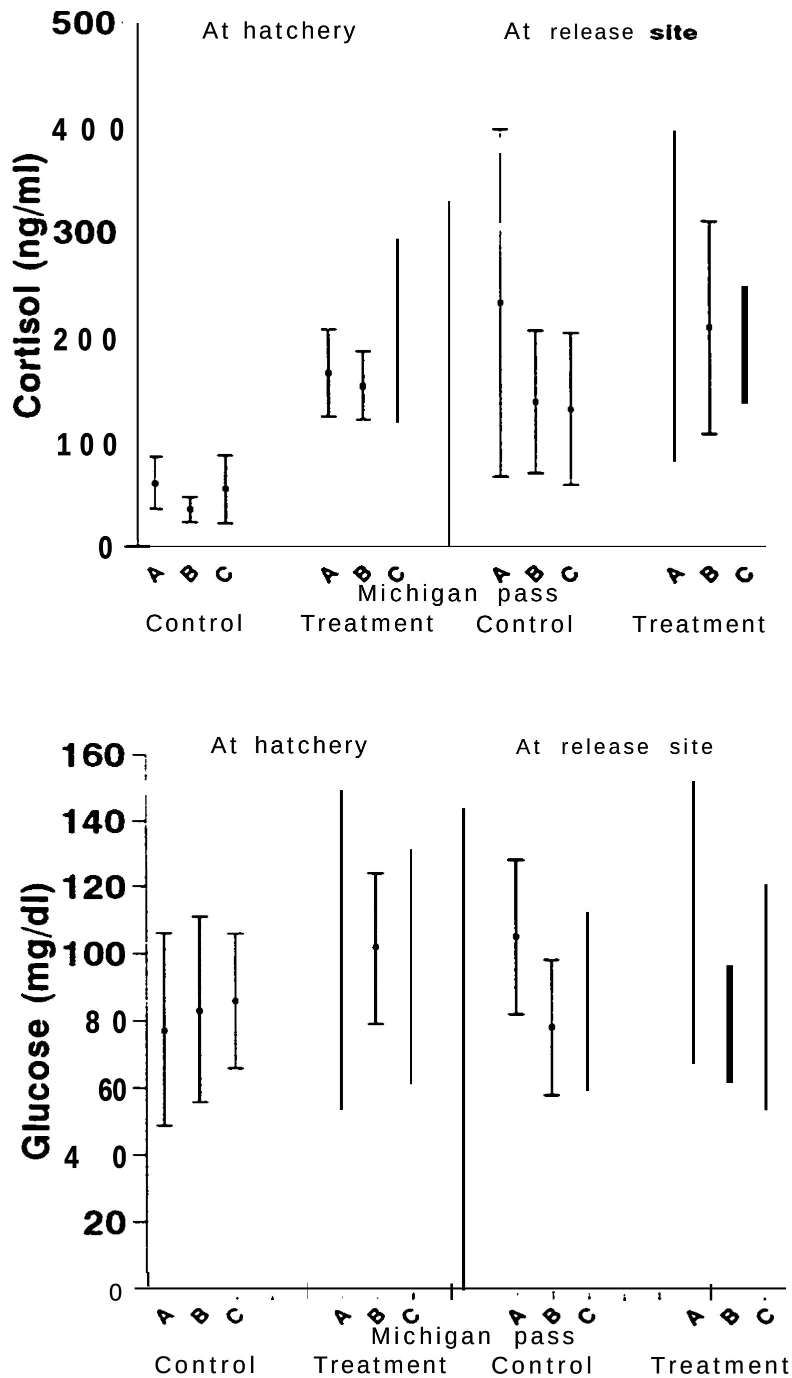


Figure 5. Mean plasma cortisol and glucose concentrations from subyearling fall chinook salmon reared in first (A), second (ES) and third pass (C) Michigan raceways at Umatilla Hatchery (1991-1994 brood years). Fish were tested at the hatchery and after transportation to the release site Treatment fish were held out of water for 30 seconds. (N = 8 for each mean, bars = 95 % confidence intervals).

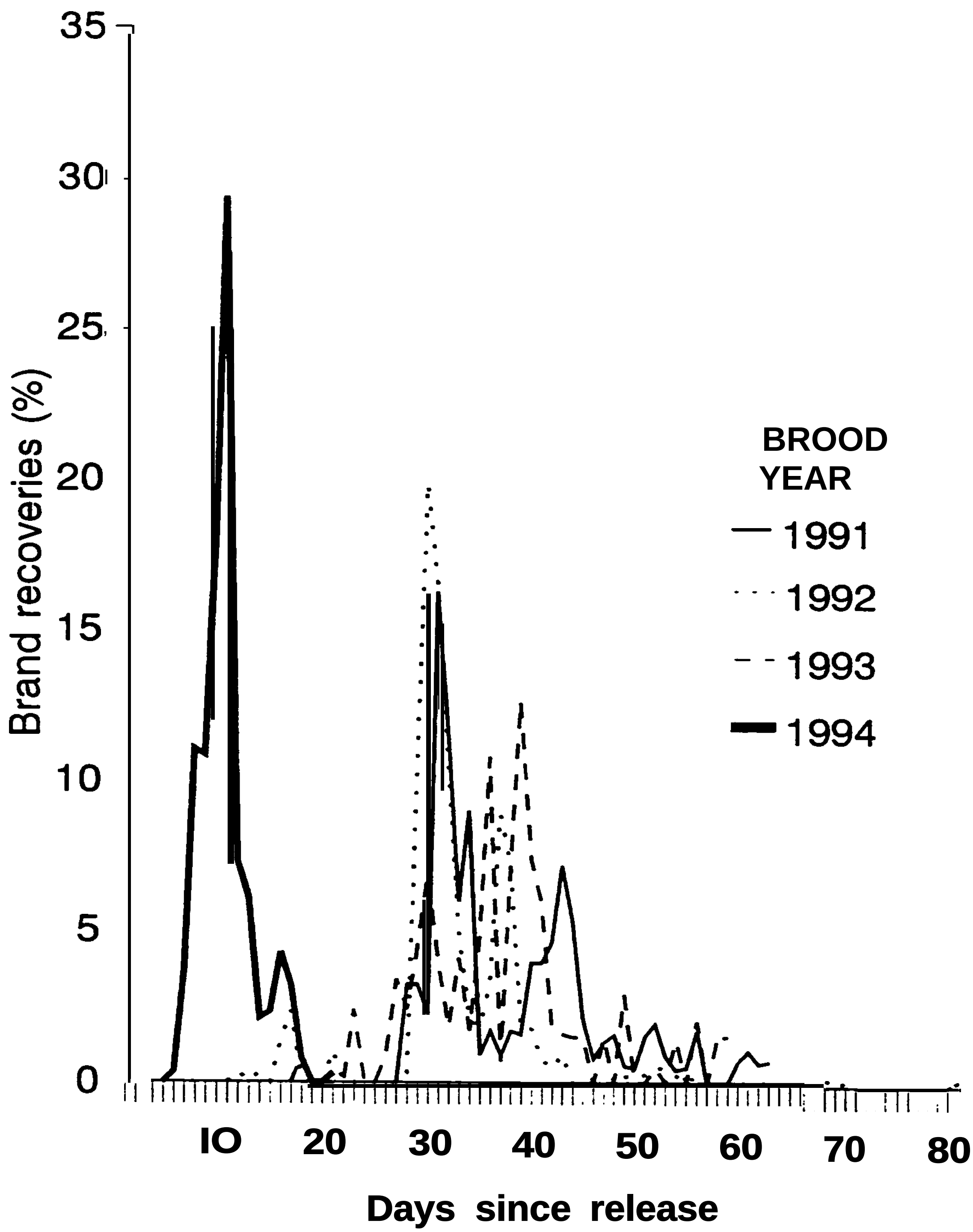
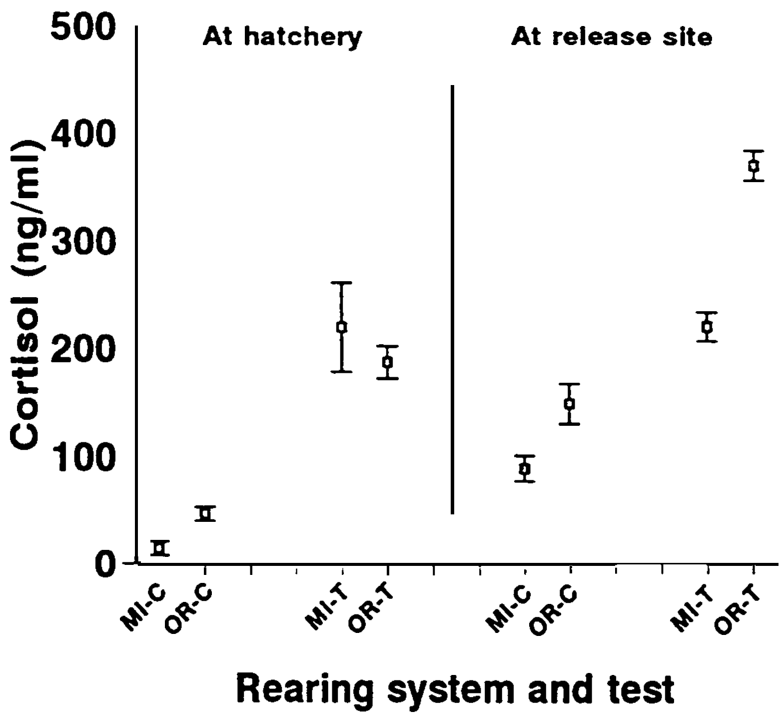


Figure 6. Branded fish recoveries for subyearling fall chinook salmon reared at Umatilla Hatchery, released in the Umatilla River and recovered at the John Day Dam from 1992 to 1995. Fish from a brood year were released in the following calendar year.



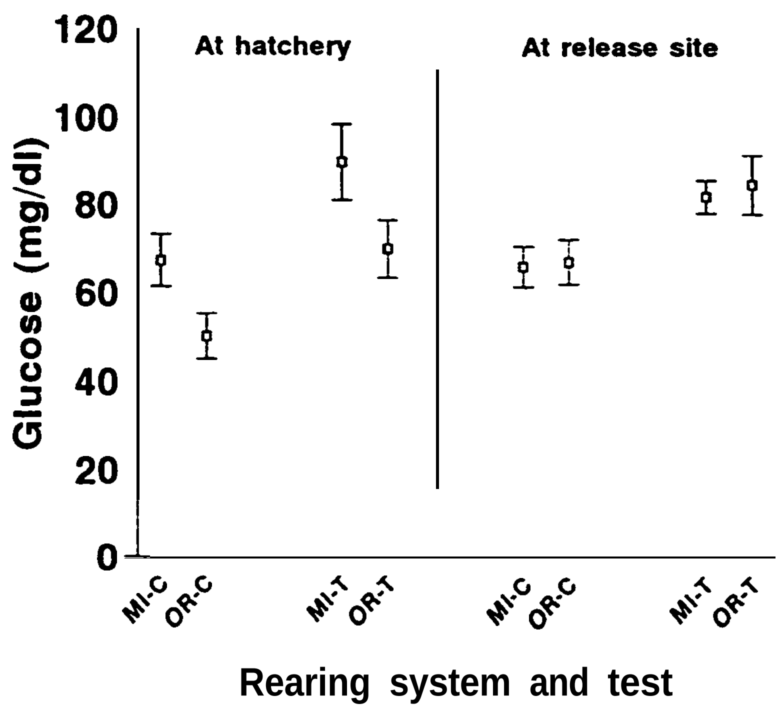


Figure 7. Mean plasma cortisol and plasma glucose concentrations for spring chinook salmon reared in Michigan (MI) and Oregon (OR) raceways at Umatilla Hatchery and released in fall 1994. Fish were tested at hatchery and at the release site immediately after transportation. (C = control, T = treatment fish were held out of water for 30 seconds, N = approximately 48 for each mean, bars = 95% confidence intervals).

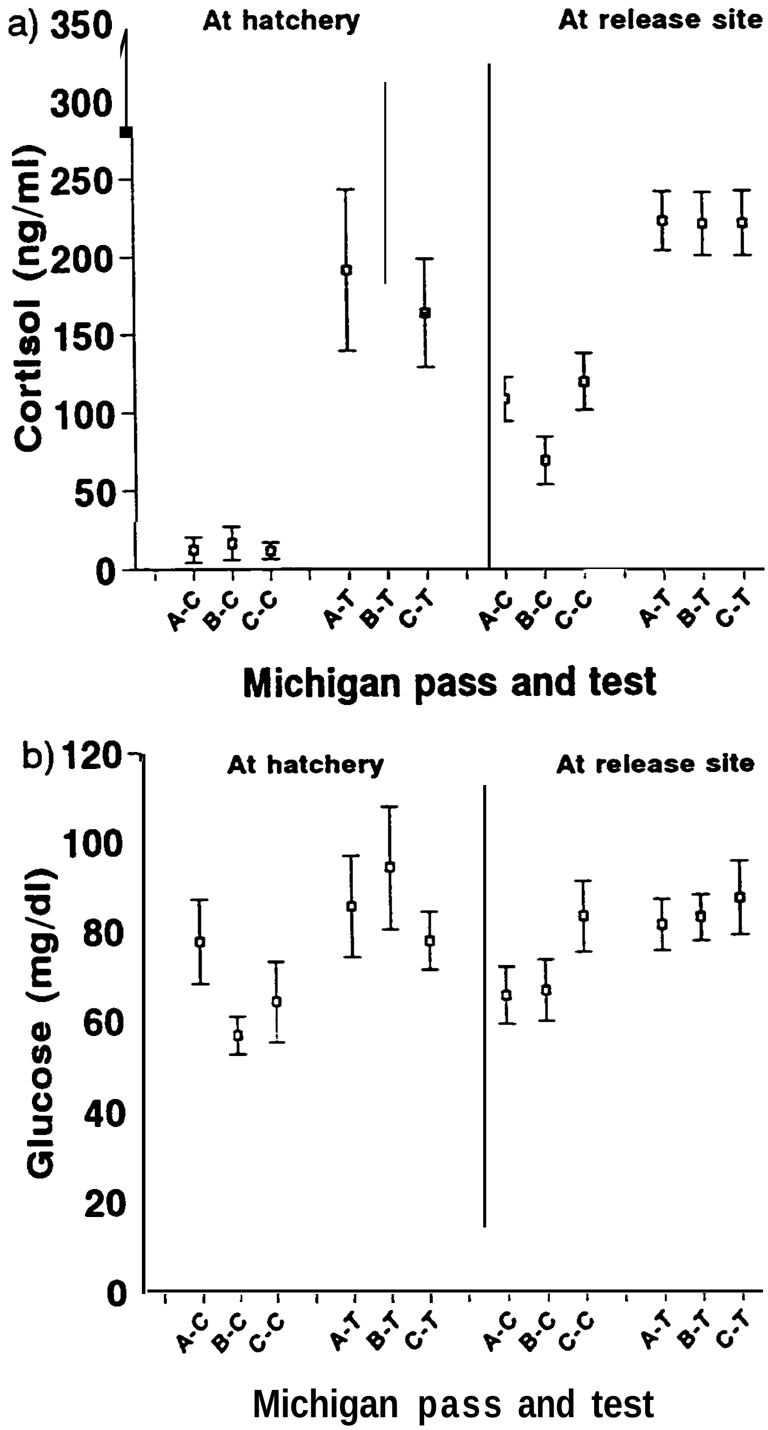


Figure 8. Mean plasma cortisol and plasma glucose concentrations from spring chinook salmon reared in in first (A), second (B) and third pass (C) Michigan raceways at Umatilla Hatchery and released in fall 1994. Fish were tested at hatchery and at the release site immediately after transportation. (C = control, T = treatment fish were held out of water for 30 seconds, N = approximately 36 for each mean, bars = 95 % confidence intervals).

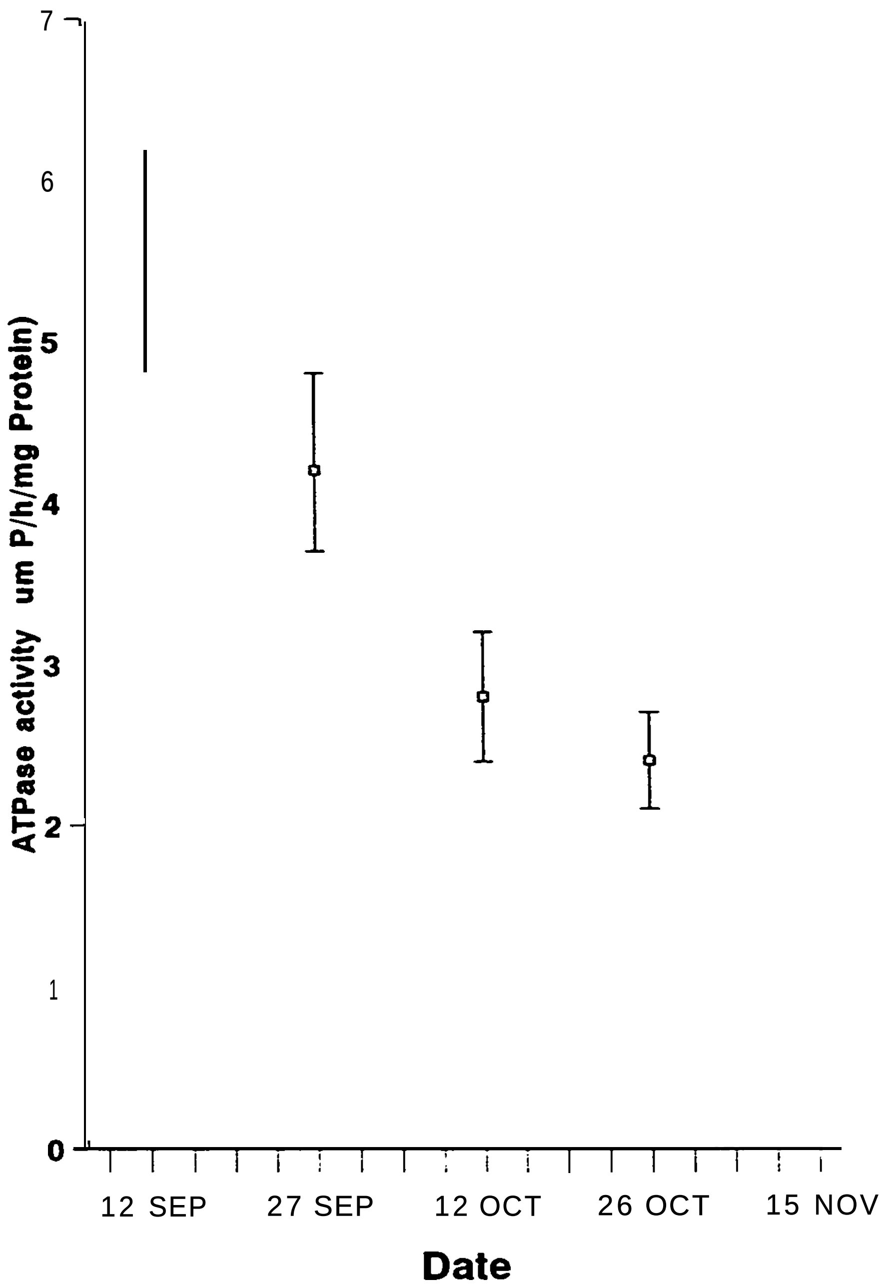
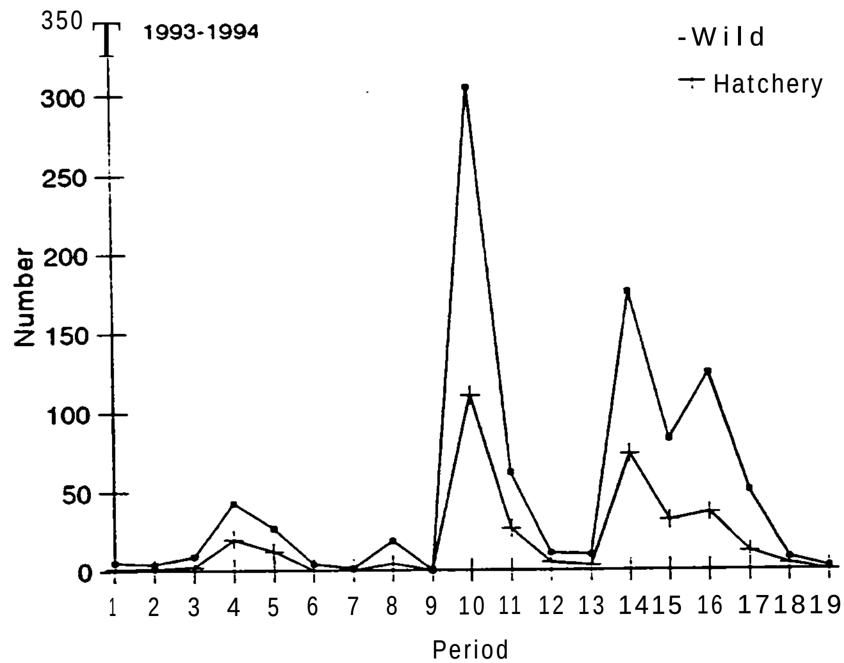


Figure 9. Gill ATPase specific activity (μm P/h/mg protein) in 1993 brood spring chinook salmon released in the fall 1994. Tests were conducted prior to release and at release (Nov 15). Bars = 95 % confidence intervals.



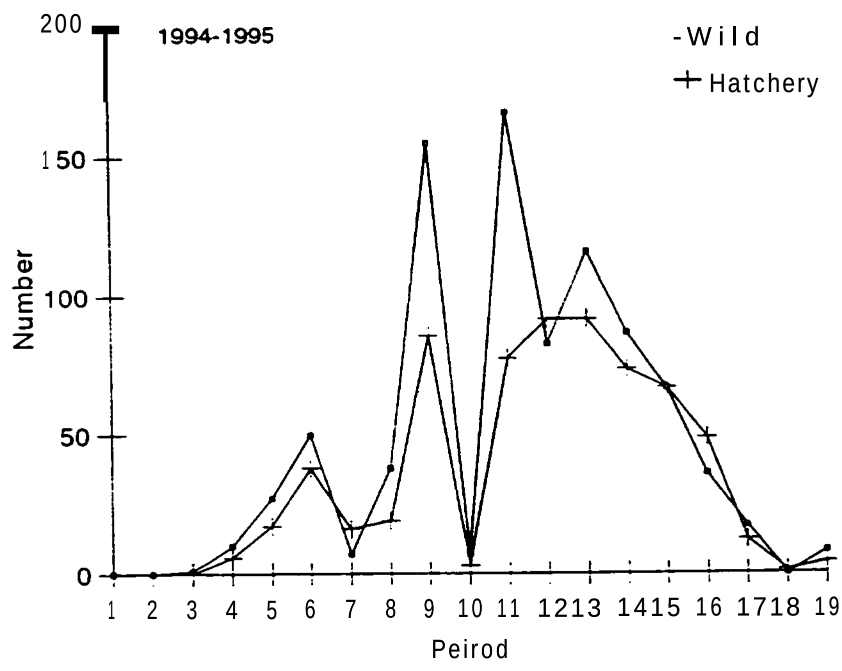


Figure 10. Run timing for adult hatchery and wild steelhead collected at Three Mile Falls Dam for 1993-1994 and 1994-1995 run years (Each period represents 2 weeks).

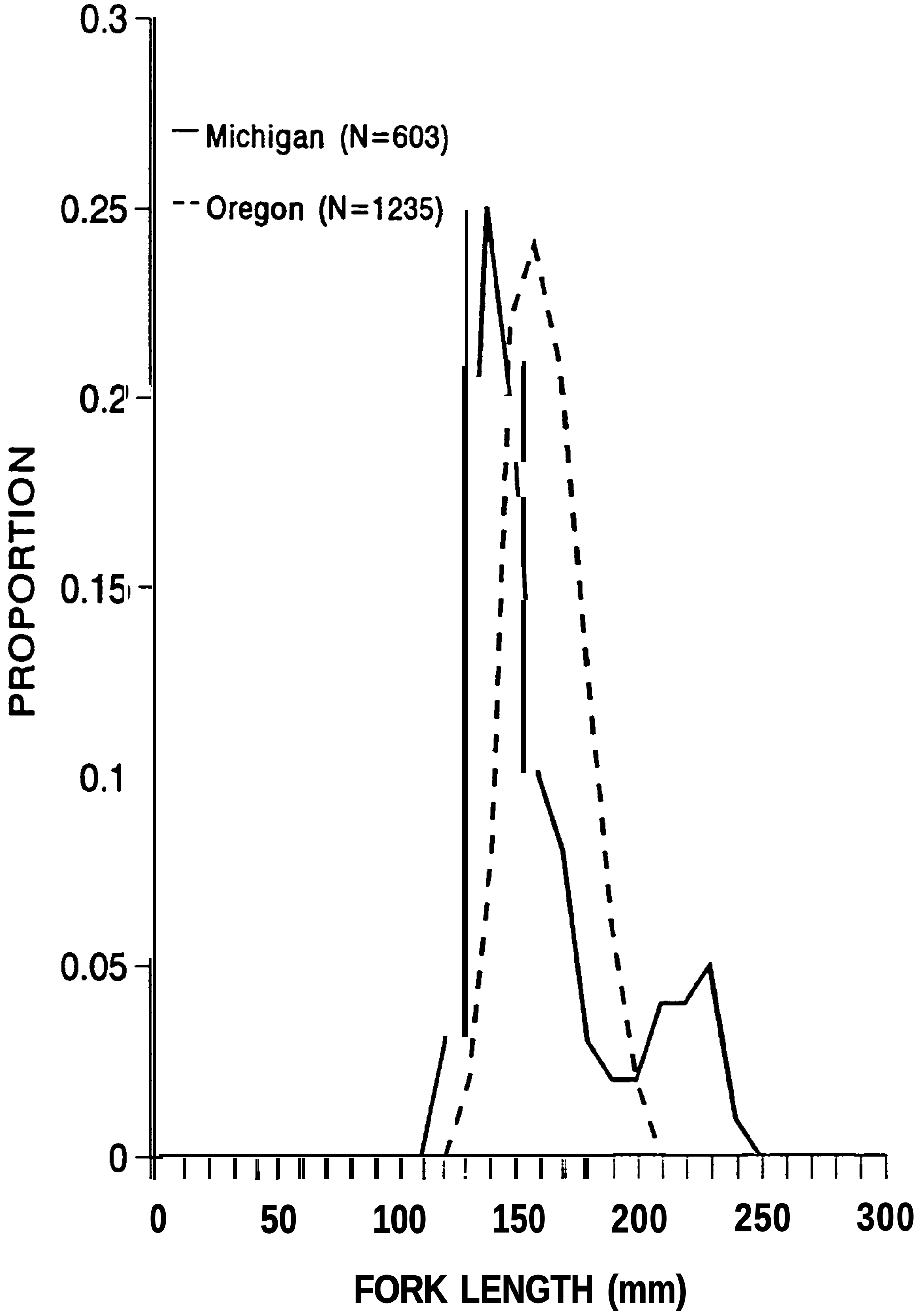


Figure 11. Length (mm) frequency distribution of spring chinook salmon yearlings (1993 brood year) reared in Michigan and Oregon raceways at Umatilla Hatchery in 1994-1995 (fish were measured one-week prior to transfer to acclimation ponds).

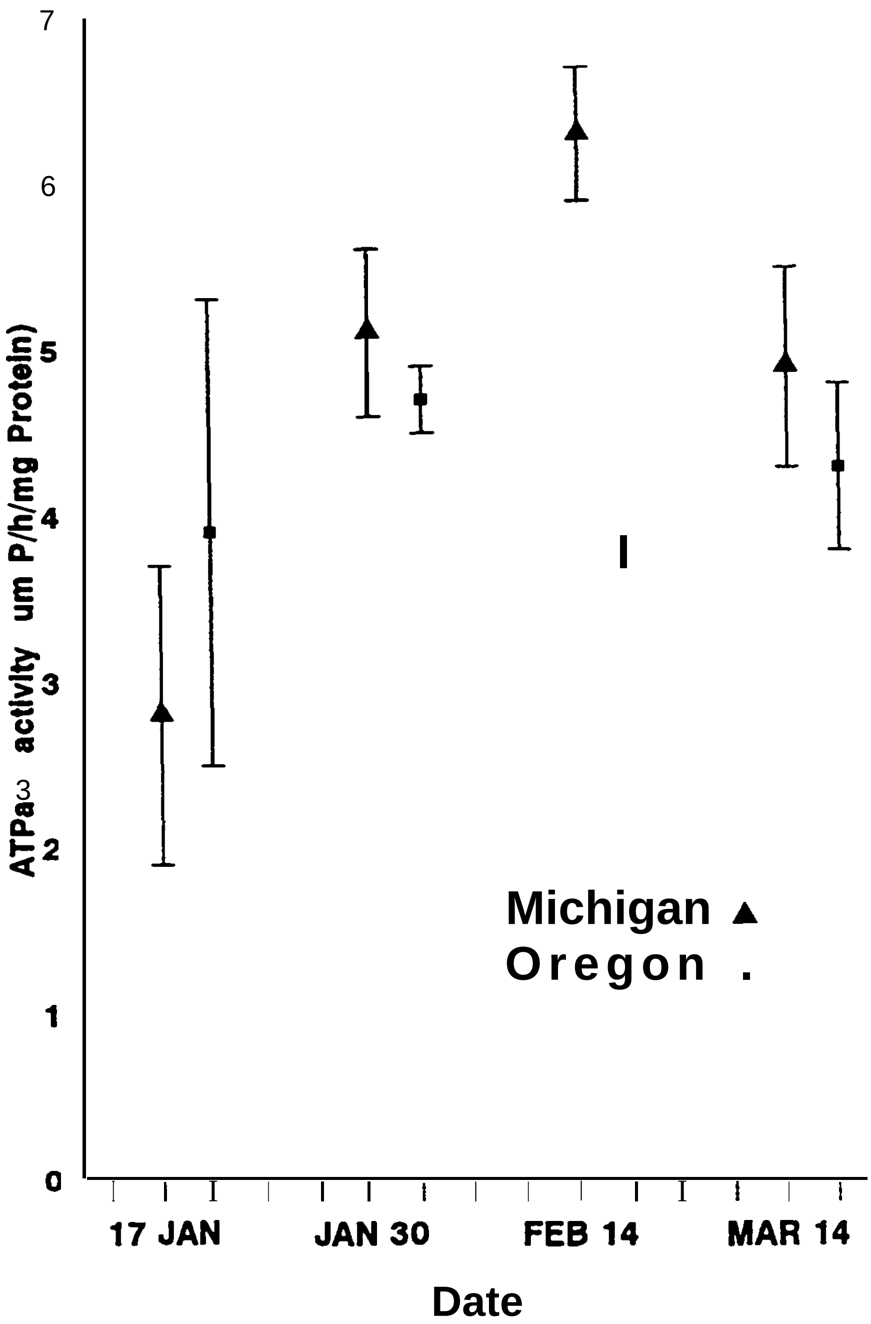


Figure 12. Gill ATPase specific activity (μm P/h/mg protein) in 1993 brood spring chinook salmon yearlings released in spring 1995. Tests were conducted prior to release and at release (Mar 14). Bars = 95 % confidence intervals.

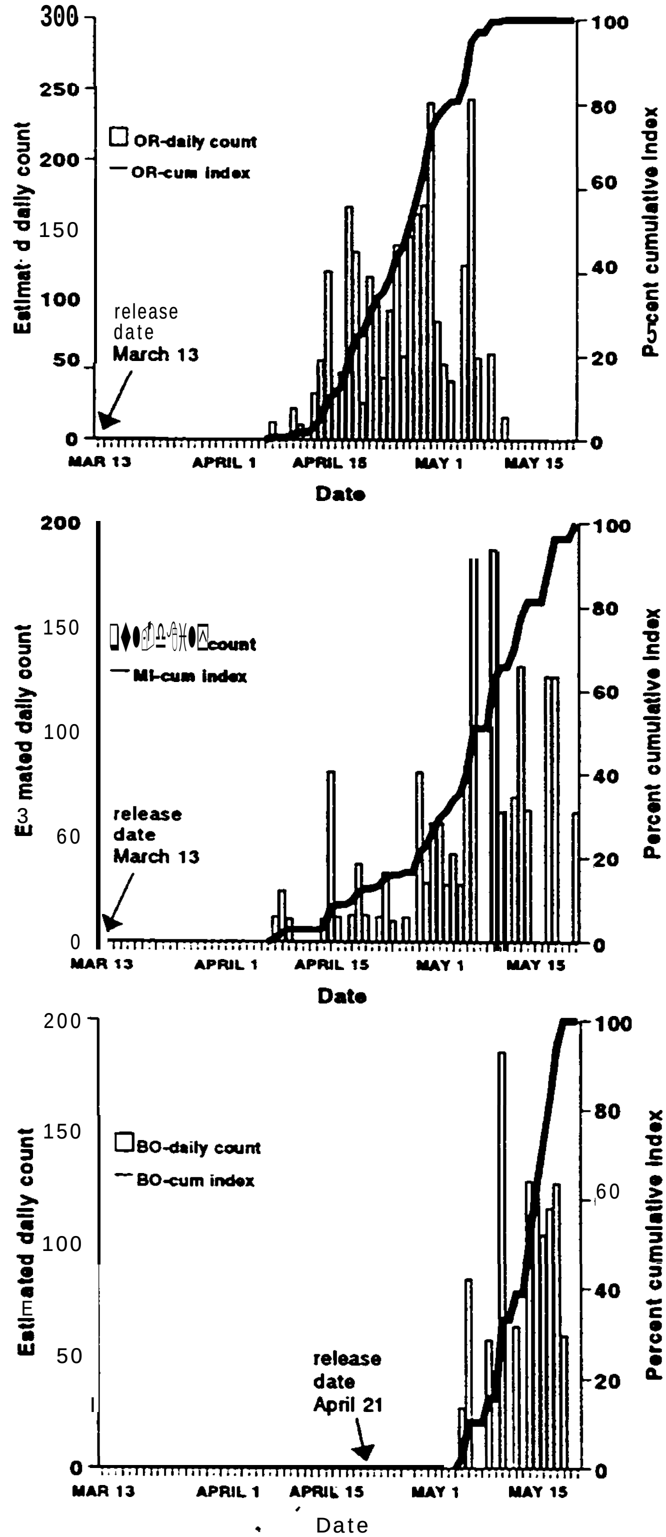


Figure 13. Estimated daily counts and percent cumulative index of branded spring chinook salmon yearlings released in the Umatilla River and recovered at the John Day Dam in 1995. Groups were reared in Oregon (OR) and Michigan (MI) raceways at Umatilla Hatchery and in Oregon raceways at Bonneville Hatchery (BO) and transferred to the Imeques-C-mem-ini-kern acclimation ponds prior to release.

REPORT B

Fish Health Monitoring and Evaluation

Prepared by:

Warren J. Groberg, Jr.
Sam T. Onjukka
Karen Waln

Oregon Department of Fish and Wildlife

FISH HEALTH MONITORING AND EVALUATION

INTRODUCTION

Fish health investigations continued as scheduled in the fourth year of studies. Spring chinook salmon adults were sampled at Lyons Ferry in the 94 and 95 brood years for Umatilla Hatchery production. The 94 brood year production was supplemented with Carson spring chinook salmon adults transferred from Lookingglass Hatchery to Wallowa Hatchery where they were spawned and sampled. Fall chinook salmon adults at Priest Rapids Hatchery were sampled and used for Umatilla Hatchery production in both the 94 and 95 brood years.

Bacterial kidney disease (BKD) was once again a problem at Umatilla, this time in the 93 brood year spring chinook salmon programmed and released as yearlings in the spring of 1995, and in the 94 brood year spring chinook salmon scheduled for release as yearlings in the spring of 1996. A loss of undetermined etiology occurred in the 94 brood year steelhead and the 93 brood year spring chinook salmon in the spring of 1995. These losses seemed to correlate to a minor drawdown of the John Day Darn pool.

Erythromycin therapy for control of BKD under Federal Drug Administration (FDA) Investigational New Animal Drug (INAD) permits continues to be a vital part of the spring chinook salmon rearing program at Umatilla Hatchery. Several treatments were administered under the INAD process.

A loss investigation was made at the new Thomhollow acclimation facility on the Umatilla River in April of 1995 on fall chinook salmon smolts transferred from Bonneville; this was the first fish health work done at that facility. A preliberation examination was conducted on spring chinook salmon smolts at the Imeques C-mem-i&kern acclimation facility in March of 1995; the third examination at that facility.

A paper on statistical analyses of enzyme-linked immunosorbent assay (ELISA) data collected for the Umatilla project was presented at the Western Fish Disease Conference in June of 1995 at Twin Falls, Idaho (Waln et al. 1995). A paper on an episode of BKD in spring chinook salmon at Umatilla Hatchery was presented in December of 1994 at the Northwest Fish Culture Conference in Sunriver. Oregon (Groberg et al. 1994).

METHODS

Methods previously described for the Umatilla Hatchery Fish Health Monitoring and Evaluation project (Keefe et al. 1993, Keefe et al. 1994, and Groberg et al. 1995) were used with one exception. Antisera for identifying ***Flexibacter psychrophilus*** was temporarily unavailable so inhibition of growth at 30°C, a nonpermissive temperature for the bacterium. was used to confirm that colonies that grew at 18°C were ***F. psychrophilus*** (Richard A. Holt personal communication).

Juvenile Monthly Monitoring

Statistical comparisons were made between A and B raceways in a series, and between **A** raceways and between B raceways for the proportion of moribund/fresh-dead 93 brood year Carson spring chinook salmon sampled during monthly monitoring from June 1994 through January 1995 **with** clinical levels of Rs antigen (> 1 .000 ELISA optical density {OD} units). A test of proportions using a z test statistic (Triola 1992) was used for these comparisons. Comparisons were made between raceways O4A and 04B, 05A and 05B, M5A and M5B. 04A and 05A. 04A and M5A, 05A and M5A, 04B and 05B, 04B and ,MSB, and 05B and M5B.

Juvenile Preliberation Monitoring

One-way analysis of variance (ANOVA) (Triola 1992) was used for statistical analysis of the log-transformed ELISA values (Ott 1977) from the 30 grab-sampled 93 brood year Carson spring chinook salmon yearlings in four Oregon raceways (04A-B and 05A-B) A t-test (Triola 1992) was used to compare similar data between the two Michigan raceways (M5A-B) of this same stock.

Juvenile Disease Outbreak Monitoring

Loss investigations were conducted during mid-February 1995 in response to two different clinical profiles exhibited by the 93 brood year Carson spring chinook salmon yearlings and the 94 brood year Umatilla steelhead yearlings. These episodes occurred simultaneously and about 10 days following a minor drawdown (0.76 m) of the John Day Dam pool between 1 and 6 February 1995. Water quality data collected before and after the drawdown event were examined to determine if there were significant changes in any water parameters that might help explain these losses. Histopathological examinations were done on lesions from three of the steelhead by Dr. Jerry R. Heidel, DVM, Ph.D., of the Oregon State University College of Veterinary Medicine. Attempts were made to reconstruct the chinook loss event 48 hours following the day it was reported.

An outbreak of BKD occurred in late September of 1994 in the 93 brood year spring chinook salmon programmed for a spring release as yearlings. A t-test (Triola 1992) was used to compare average daily mortality rates during the onset of this loss from 15-30 September. Comparisons were made between each Oregon A and B raceway in a series to determine if the lower raceways were an earlier indicator of a problem. Losses in the Michigan raceways containing this stock were not nearly as severe and no such analysis seemed appropriate.

Investigational New Animal Drug Monitoring

An unscheduled erythromycin treatment was again needed to control BKD in the 93 brood year Carson spring chinook salmon programmed as yearlings as it was for the 92 brood year fish of this **stock. An amendment to the MAD** protocol for these fish was authorized by Dr. Christine M. Moffitt of the University of Idaho. This allowed a 21 day feeding in October-November 1994 at a target dosage of 100 mg per kg body weight per day while these fish were in four Oregon and two

Michigan raceways. A review of the INAD protocol indicated that the fish in the Oregon raceways had not received an initial 21 day feeding in July as planned. The fish in the two Michigan raceways received an initial erythromycin feeding in April under the MAD protocol for the fall release fish of this stock. A planned final feeding was administered in January and all feedings were followed by toxicity tests. The entire BKD episode in this stock incorporated elements of INAD, monthly and disease outbreak monitoring.

One-way ANOVA was used to make comparisons of the average daily mortality rates among four Oregon raceways (04A-B and 05A-B) during the three months of this episode from 15 September to 15 December 1994. A t-test was used to compare the average daily mortality between the two Michigan raceways, and between Oregon and Michigan raceways over the same period (Statistical comparisons between the Oregon and Michigan raceways were compromised since it was determined that the fish in Oregon and Michigan raceways did not originate from a common population. The fish in Michigan raceways were ponded in February 1994 in OlA and fish in Oregon raceways were ponded in May 1994 in 05A). Combined daily mortality for Oregon raceways 04A and B were compared to combined Michigan raceways M5A and B, and combined Oregon raceways 05A and B were also compared to combined Michigan raceways M5A and B.

Broodstock Monitoring

Adult fall chinook salmon for the 94 brood year program at UmatiIIa were sampled at Priest Rapids on 10 and 14 November 1994. Adult spring chinook salmon for the 94 and 95 brood year Carson spring chinook salmon production at Umatilla were sampled at Lyons Ferry in both years. Brood year 94 adults were sampled on 24 and 31 August, and 7 and 14 September 1994. Brood year 95 adults were sampled on 6 September 1995. Carson adults held at Wallowa Hatchery were used to supplement the 94 brood year production and those were sampled at Wallowa on 23 and 30 August, and 6 September 1994.

RESULTS

Juvenile Monthly Monitoring

Necropsies

External parasites were not detected in wet mounts of gills or body scrapings from a total of 164 moribund/fresh-dead fish and 180 grab-sampled healthy fish examined by microscopy. Occasional gill aneurysms and areas of hyperplastic filaments were observed on moribund/fresh-dead and grab-sampled fish. The single monthly monitoring of the fall chinook salmon on 5 April 1995 revealed unusually high levels of motile bacteria in body scrapings from both moribund/fresh-dead and grab-sampled fish. Gill cultures from the moribund/fresh-dead fish made on that date also produced low to high levels of motile bacteria from 30/33 (90.9%) of the fish cultured. These were different than the yellow pigmented typical gill disease bacteria isolated from 12/33 (36.4%) of these fish at the same time (Appendix Table A-5). Seven of 33 (21.2%)kidney smears made on NE agar produced colonies of ***F. psychrophilus*** (Appendix Table A-5), the agent of bacterial cold water disease (CWD). This bacterium was not detected systemically in any of 50 steelhead (Appendix Table A-4), but was isolated from 3/198 (1.6%) of the spring chinook salmon tested (Appendix Table A-6). Typical gill disease bacteria were isolated from 6/22 (27.3 %) of the steelhead (Appendix Table A-4) and from 7/l 16 (6.0%) of the spring chinook salmon (Appendix Table A-6). Erythrocytic inclusion body syndrome (EIBS) inclusions were not seen in any of 78 blood smears made from moribund/fresh-dead chinook salmon nor from any of 130 grab-sampled chinook examined.

***Assays* for *Renibacterium salmoninarum* by the ELISA and DFAT**

Thirty-six moribund/fresh-dead and 30 grab-sampled normal appearing 94 brood year Umatilla summer steelhead were tested by the ELISA for Rs during the seven months of monthly monitoring (Appendix Table A-7). Kidney tissue from these fish was homogenized at a 1:7 or 1: 15 dilution. The mean OD reading for the moribund/fresh-dead steelhead was 0.047 and the range was 0.002-0.412. Five fish had OD values in the very low level positive range (0.113, 0.137, 0. 176, 0.176 and 0.183) while two had moderate Rs positive values (0.318 and 0.412). The mean for the 30 grab-sampled steelhead was 0.071 and the range was 0.001-0.538. Four of these 35 fish had Rs positive OD values of 0.100, 0.120, 0.153 and 0.183, while three had moderate OD readings of 0.306, 0.362 and 0.538.

Thirty-three moribundffreshdead and 15 grab-sampled 94 brood year fall chinook salmon from two Oregon and three Michigan raceways were examined in April for Rs by the DFAT (Appendix Table A-8); all 48 were negative.

During monthly monitoring 200 moribund/fresh-dead spring chinook salmon of the 93 brood year, programmed as yearlings, from four Oregon (O4A-B and O5A-B) and two Michigan (M5A-B) raceways were examined from July 1994 through January 1995 (Appendix Table A-9). The prevalence (Figure 1) and proportion of these fish with clinical levels of Rs (> 1 .000 OD units) from moribund/fresh-dead fish by month, including April through June monitoring, were as follows: April 0% (0/5 - all examined by the DFAT), May 0% (0/10 - five examined by the DFAT and five examined by the ELISA), June 0% (0/10), July 0% (0/15), August 43.3% (13/30), September 53.3% (16/30), October 80.0% (24/30), November 23.1% (3/13), December 73.3% (22/30) and January 76.0% (19125). In grab-sampled fish during this period 3.2% (4/125) had clinical levels and 3.2% (4/125) had OD values between 0.400 and 1 .000. The prevalences and proportions of the moribund/fresh-dead fish with clinical levels of antigen, by raceway, are shown in Table 1.

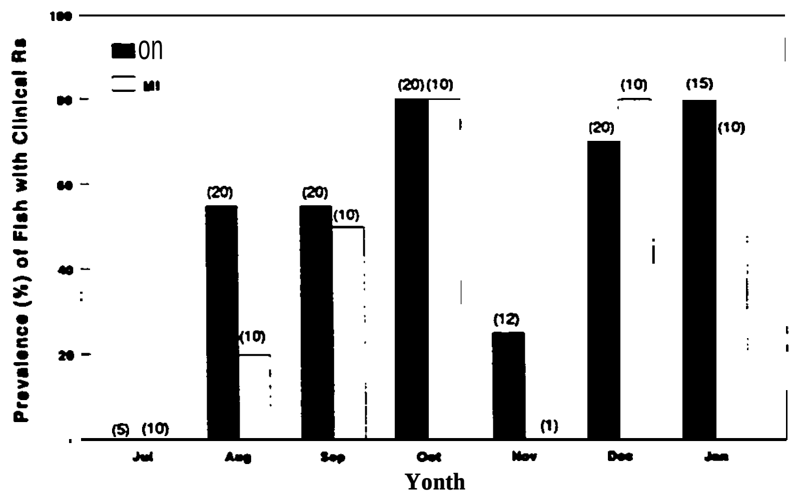


Figure 1. Prevalence (%) of moribund/fresh-dead 93 brood year Carson spring chinook salmon with clinical levels of Rs antigen (> 1 .000 OD units) as determined by the ELISA during monthly monitoring from July 1994 through January 1995. The fish were from four Oregon and two Michigan raceways at Umatilla Hatchery. Sample size is indicated in parentheses.

Table 1. Prevalence (%) and proportion of moribund/fresh-dead 93 brood year Carson spring chinook salmon juveniles with clinical levels of Rs antigen (> 1 .000 OD units) as determined by the ELISA (DFAT results were used for 05A in May) during monthly monitoring from May 1994 through January 1995. The fish were from Oregon series O4A-B and O5A-B, and Michigan series M5A-B at Umatilla Hatchery. The difference between the A and B raceways of each series were statistically significant ($p \leq 0.001$, $p \leq 0.001$ andp ≤ 0.005, respectively). No significant differences were found between any of the A raceways nor between O4B and M5B. Significant differences were found between O4B and O5B, and between 05B and M5B (p IO.050 and 0.048, respectively).

	Fish with Clinical Levels of Rs Antigen	
Raceway	Prevalence (%)	Proportion
O4A	32.4	11/34
O4B	61.5	16/26
05A	43.2	19/44
O5B	75.0	21/28
M5A	36.7	11/30
M5B	61.3	19/31

Juvenile Preliberation Monitoring

Necropsies

External parasites were not detected in wet mounts of gills or body scrapings examined by microscopy from a total of 14 fish from all species and stocks. Gill condition was normal by gross examination. No culturable viral agents were detected by cell culture assays. Four-hundred eighty blood smears from chinook salmon stocks at Umatilla Hatchery were negative for EIBS inclusions. At Bonneville Hatchery, 2.5% (3/120) of the 93 brood year Carson spring chinook salmon yearlings had a low level (l-2 inclusions per microscope field) of typical EIBS inclusions.

Assays for *Renibacterium salmoninarum* by the ELISA

All 90 of the Umatilla 94 brood year summer steelhead juveniles tested for Rs by the ELISA had OD readings at or below 0.040 (Appendix Table A-10). Mean OD's for the 30 fish from each raceway were 0.012, 0.009 and 0.012 for M8A, M8B and M8C, respectively.

Three of 300 (1 .O %) Priest Rapids 94 brood year fall chinook salmon juveniles from four Oregon and six Michigan raceways had OD readings between 0.100 and 0.133: the remaining 297 had OD values at or below 0.095 (Appendix Table A-l 1). Mean OD readings for the 30 fish from each Oregon raceway were 0.042, 0.022, 0.020 and 0.021 for O2A, O2B, 03A and O3B, respectively. For the six Michigan raceways mean OD's were 0.020, 0.015, 0.024, 0.019, 0.028 and 0.025 for M2A, M2B, M2C, M3A, M3B and M3C, respectively. Kidneys from these fish were processed at a 1:15 dilution because of their small size.

The ELISA values obtained with the 93 brood year Carson spring chinook salmon yearlings in four Oregon and two Michigan raceways were predominantly at or below 0.100 (Appendix Table A-12). Ninety-three percent (279/300) were in this very low range. Of the remaining 21 fish, five (1.7%) were in the 0.100-0.199 range, nine were in the 0.200-O-399 range (3.0%), four (1.3%) had readings in the 0.400-0.599 range and three (1.0%) had clinical levels greater than **1.000** OD units. Means were 0.052, 0.043, 0.192 and 0.082 for O4A, O4B, 05A and O5B, respectively. Means for the two Michigan raceways were 0.023 for M5A and 0.085 for M5B. No significant statistical differences were found among the ELISA distributions for the four Oregon raceways ***($p \geq 0.1264$).*** A significant difference was found between the two Michigan raceways ($p \leq 0.0378$).

Preliberation examinations were done on 15 February and 22 March 1995 at Bonneville on the 93 brood year spring chinook salmon yearlings prior to transfers to the Umatilla River. Sixty grab-sampled fish from each date were assayed by the ELISA. All 120 fish had OD values less than 0.080 (Appendix Table A- 13).

A preliberation examination was conducted on 10 March 1995 at Imeques C-mem-ini-kern on acclimated 93 brood year spring chinook salmon yearlings transferred from Umatilla Hatchery in late February. Five grab-sampled and five moribund/fresh-dead fish from each of the four ponds were examined. All 20 grab-sampled and nine moribund were negative for EIBS. The gills were in good condition and no external parasites were seen by microscopy. No fish-pathogenic bacteria were isolated on culture media from smears of gills. ***Seven F. psychrophilus*** colonies were isolated from a kidney smear from 1/20 moribund/fresh-dead fish tested. ELISA OD's of the grab-sampled fish showed 18/20 in the less than 0.100 range, one at 0.504 and one at 0.921. Of the 20 moribund/fresh-dead fish examined, 12 were less than 0.100 OD units, one was at 0.191, two were in the 0.200-0.299 range, one at 0.738 and four were above 2.000 OD units, well above the clinical range.

Juvenile Disease Outbreak Monitoring

On 13 February 1995 hatchery personnel reported observing large numbers of the steelhead in MBA-C with a mottled appearance, possibly external fungus. On the following morning spring chinook salmon yearlings from MSA-B were being transferred to the Imeques C-mem-ini-kem acclimation pond. Upon releasing a load into the ponds personnel observed several thousand dead fish. A truck loaded with fish from MSA-B was enroute and was recalled to the hatchery. Upon offloading the fish back into the raceways there were several hundred dead fish.

Examinations of the steelhead on 14 February indicated that the mottled appearance was due to sloughing of mucus and scales, and in many cases complete loss of the skin from large areas of the body surface. These lesions subsequently developed fungal lesions and resulted in considerable loss over the next several weeks. No etiological agent was isolated nor was any observed in lesions examined by histopathology. The lesions were not inflamed, contraindicating an infectious agent or toxic reaction, and the most consistent histopathological feature was lifting of the scales. Given that the fish were in a smoking condition, a chemical or osmotic imbalance was suspected. An identical clinical syndrome was diagnosed in the steelhead yearlings at Irrigon Hatchery, immediately adjacent to Umatilla Hatchery, on 7 February 1995, one week earlier than the occurrence at Umatilla. Both hatcheries use well water, but not from a common well at the time of this episode.

Sixty of the spring chinook salmon that were dead or moribund after being recalled to the hatchery and offloaded were examined for gross pathological signs. Pale liver was the only sign observed and was the common feature among these. Jaundiced (yellow-orange) liver is one of the clinical signs observed with erythromycin toxicity (Faler and Moffitt 1993). These fish had received their last erythromycin feeding 16 days earlier and the livers were pale, not jaundiced. Toxicity tests following that feeding revealed that 43.3 % (26/60) of fish tested showed signs of toxicity on the first day following the last feeding day, none showed toxicity on day three, 1.7 % (1/60) had a fatal toxicity reaction on day seven, and none showed toxicity on day 14 tests. Similar to the steelhead, no etiological agent was detected. On 17 February 1995 attempts were made to reconstruct the loss in the chinook by holding approximately 50-fish groups out of water in a net for 30 seconds and then holding them for observation in a livebox in the raceway. This was done with a total of approximately 150 fish. No morbidity or mortality was induced by these actions. On 21 February transfers were resumed to acclimation ponds with no unusual losses reported.

Water chemistry data were generously provided by Mike Hayes and staff of the Hermiston ODFW Research Section who conduct that part of the Umatilla Hatchery Monitoring and Evaluations. The parameter that appeared to change significantly before and after the drawdown of the John Day pool between 1 and 6 February 1995 was alkalinity. The alkalinity range for the steelhead raceways, M8A-C, determined during routine monitoring on 23 December 1994 was from 110.5 to 113.0 mg/L CaC03. These values from the same raceways on 2 February 1995 were 113.7 to 124.1, and on 15 February they were from 13 1.6 to 135 .O. It is not known how quickly these changes occurred. Reportedly, changes in alkalinity were measured following previous drawdown events (Mike Hayes personal communication). There was no dramatic change in pH at these same sample sites and times.

A response to an increased loss in 93 brood year fall chinook salmon yearlings at the new Thornhollow acclimation facility was made on 5 April 1995. These had been transferred from

Bonneville in late March and losses were reportedly occurring a the rate of 20-40 fish per day among the three ponds. Eight of 10 moribund/fresh-dead fish examined had clinical signs of BKD and these eight had ELISA OD values from 1.558 to 3.218, all well into the clinical range. No treatments were recommended.

Statistical analyses of average daily mortality rate during the onset of a BKD outbreak in the 93 brood year spring chinook programmed as yearlings indicated significantly higher losses in the B Oregon raceway than in the comparable A Oregon raceway. In O4A and O4B the daily loss from 15-30 September was 0.012 and 0.026%. respectively ($p \leq 0.005$) For 05A and 05B these values were 0.010 and 0.017, respectively (p 50.029).

Investigational New Animal Drug Monitoring

Analyses of the erythromycin lot used for feeding the spring chinook salmon yearlings discussed above indicated the diet contained 120% of the targeted erythromycin level (Alf Haukenes, INAD Field Trial Coordinator records). At the feeding rate (2.8% body weight) used (INAD 4333 Use Report for Protocol 95 OR UM SCS-1) the fish would have received a dose of 149 mg per kg body weight per day. Recommended levels are 100 mg per kg per day.

The daily mortality from 15 September to 15 December 1994 for the 93 brood year Carson spring chinook salmon yearlings is shown in Figure 2 for the four Oregon raceways and Figure 3 for the two Michigan raceways. Among the four Oregon raceways during these three months, the average daily mortality was significantly less for O4A (0.0217%/day) than for O4B (0.0604%/day), for O5A (0.0598%/day) and for 05B (0.0552%/day), ($p \leq .001$). There was no difference between Michigan raceways (M5A and M5B both at 0.010%/day). By using the average daily mortality for each Oregon series combined (0.041 %/day for O4A-B and 0.058%/day for O5A-B) and the two Michigan raceways (M5A-B) combined (0.010%/day), the Michigan raceways were found to be significantly lower in each comparison ($p \leq .001$ for the 04 and 05 series). Graphically, this is also very evident (Figures 2 and 3).

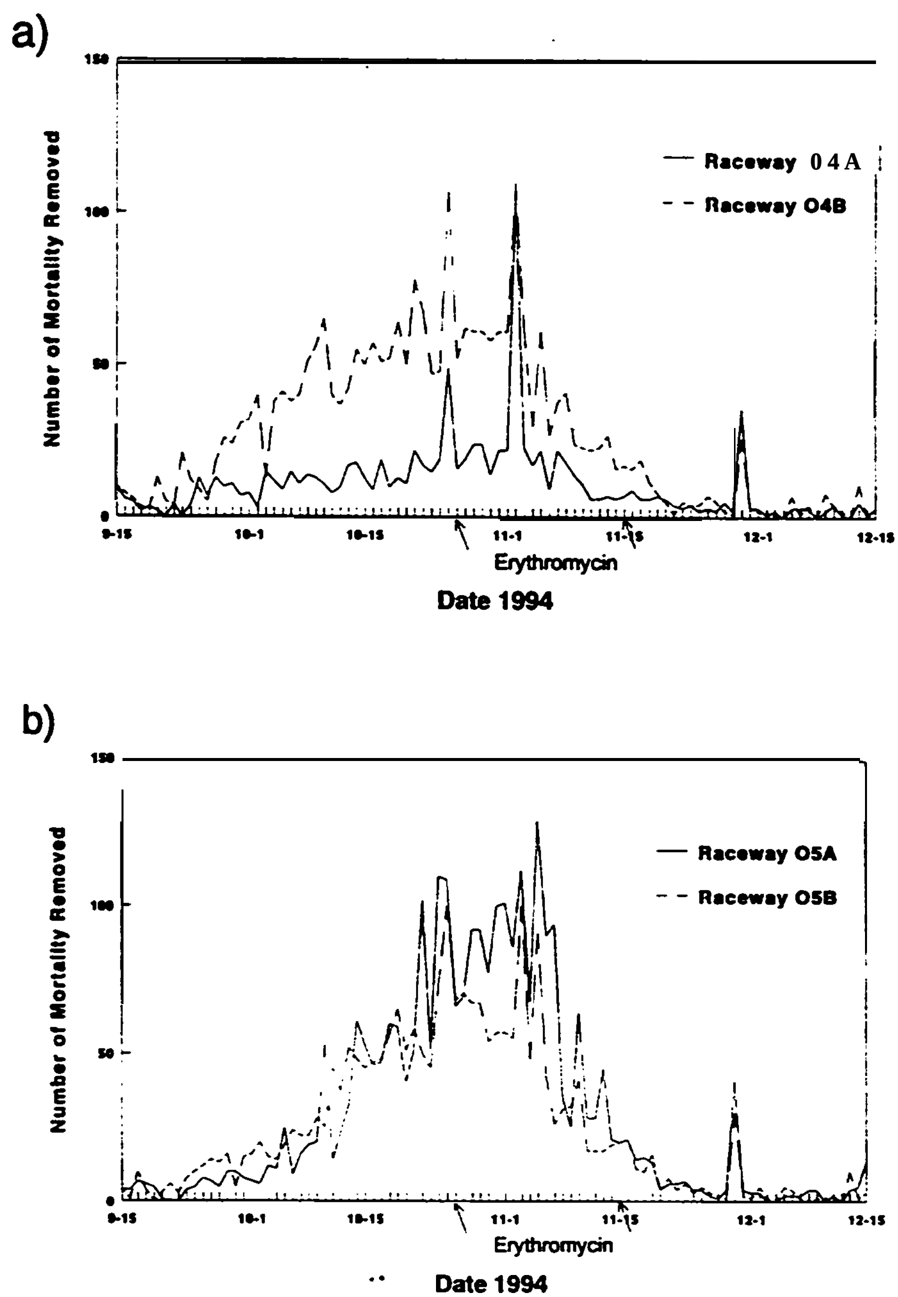


Figure 2. Numbers of 93 brood year Carson spring chinook salmon mortality, programmed as yearlings, removed daily from Oregon raceways O4A-B (Graph a) and O5A-B (Graph b) between 15 September and 15 December 1994. Arrows indicate the start and end of erythromycin feeding.

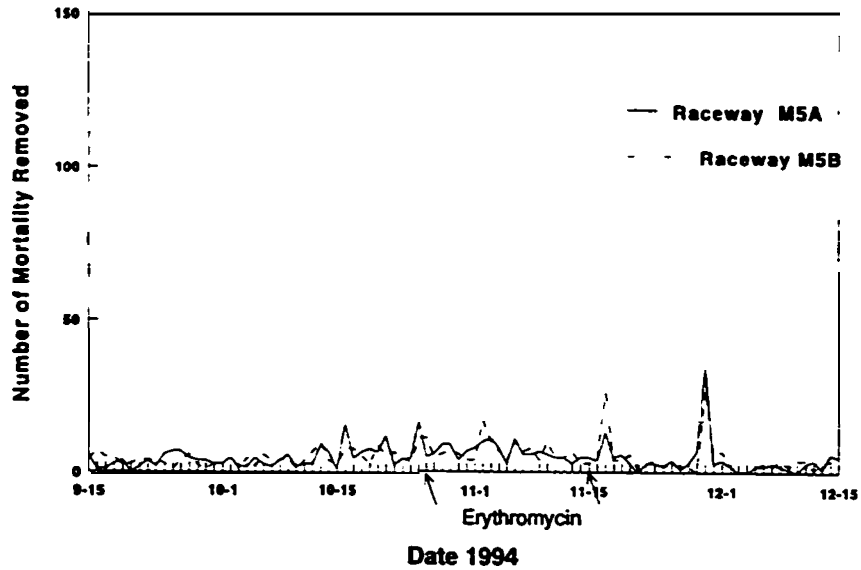


Figure 3. ***Numbers*** of 93 brood year Carson spring chinook salmon mortality, programmed as yearlings, removed daily from Michigan raceways **M5A-B** between 15 September and 15 December 1994. Arrows indicate the start and end of erythromycin feeding.

Following the completion of the 21day amended erythromycin feeding of these fish on 15 November 1994, there was a marked decline in daily mortality in the Oregon raceways (Figure 2). Although not as dramatic, there was also a decline in the two Michigan raceways (Figure 3). The spike in mortality for all raceways on 29 November is **attributed** to monthly activities which involved disturbing, crowding and handling fish over two consecutive days. There was again a slight increase in mortality during early January 1995 and a **scheduled** etythromycin feeding from 9-31 January reduced this to daily levels in the range from **0-10** fish per day until their release in February.

Broodstock Monitoring

Infectious hematopoietic necrosis virus was detected in **19/4 1** (46.3 **%)** individual ovarian fluid (OF) and **7/40** (17.5%) individual milt **(M)** samples collected from spawned **Umatilla** summer steelhead at **Minthorn** ponds providing fertilized eggs for the 95 brood year (Appendix Table A-16). **This** sampling represented 100% of the spawned adults. The virus was also detected in **11/31** (35.5%) of pyloric **caeca/kidney/spleen (PKS)** sample pools from these same fish. An isolate was confirmed to be a Type 2 strain in an indirect fluorescent antibody test **(IFAT)** using the 105B **monoclonal** antibody which is specific for this strain Sixty-five spawned steelhead adults (Appendix Table A-14) and 39 adult mortality (Appendix Table A-15) were **sampled for Rs** by the ELISA. Fifty-seven spawned adults had OD values less than 0.100, six were in **the 0.100-0.199** range, one had a reading of 0.349 and one had a very high clinical reading of 3.056. Upon excising a kidney sample from the male with the 3.056 OD value no abnormal signs in the kidney were observed. In adult mortalities, 37 had ELISA readings below 01.00 and **two** were in the 0.100-O. 199 range. External fungus was the predominant clinical sign on the adult mortality which had not been treated with formalin.

Broodstock providing eggs for the 94 brood year fall chinook salmon at Umatilla were spawned on 10 and 14 November 1994. Representative subsamples of the spawned population were sampled on each date. Forty three-female OF samples, forty three-male M samples and 12 five-female PKS samples were negative for replicating agents -when assayed on cell cultures (Appendix Table A-18). Twenty blood smears from each spawning date were negative for EIBS inclusions (Appendix Table A-19). Forty kidneys were randomly collected from females. One of these had an ELISA reading of 0.246, three were in the 0.100-0.199 range and the remaining 36 were below 0.062 OD units (Appendix Table A-17).

Fall chinook salmon adult females were spawned at Bonneville Hatchery for 94 brood year production. All fish health sampling data on these are courtesy of Clackamas and Corvallis ODFW Fish Pathology personnel. They were sampled for II-IN virus between 1 November and 9 December 1994 (Appendix Table A-30). Fifty-five of the 116 (47.7%) three-female OF sample pools, none of the 12 five-female PKS ample pools and 5/28 (17.9%) of five-female gill sample pools were positive for II-IN virus (Appendix Table A-30). Twenty blood smears for EIBS examination from males and females were also taken on each spawning date for a total of 120 for each sex (Appendix Table A-31). No females were positive and 9/120 (7.5 %) of males were positive. Kidney samples from 908 fish were assayed by ELISA for Rs (Appendix Table A-29). By OD range, the percent distribution of these is as follows: 4.19% > 1.000, 0.55% = 0.800-0.999, 1.21% = 0.600-0.799, 1.32% = 0.400-0.599, 1.54% = 0.200-0.399, 3.97% = 0100-0.199 and 87.22% < 0.099.

Eggs for Umatilla Hatchery 94 brood year spring chinook salmon production were predominantly from fish collected at Ringold and held at Lyons Ferry Hatchery. These were spawned and sampled between 24 August and 14 September 1994. One-hundred forty-six individual OF samples and 145 individual M samples collected from Lyons ferry adults were negative for replicating agents (Appendix Table A-21). Sixteen four-female PKS samples were also negative (Appendix Table A-22). Seventy-one blood smears from Lyons Ferry females were negative for EIBS inclusions (Appendix Table A-22). Seventy-one kidney samples from Lyons Ferry females were assayed for Rs by the ELISA; one had an OD reading of 0.520 and the remaining 70 were 0.044 and below (Appendix Table A-20).

Twenty-four Carson adults from Lookingglass Hatchery were held and spawned at Wallowa Hatchery to supplement the 94 brood year spring chinook salmon egg takes at Lyons Ferry. These were spawned on 23 and 30 August, and 6 September 1994. Four of 24 (16.7%) individual OF and 3/24 (12.5%) individual M samples were IHN virus positive (Appendix Table A-27). One of eight (12.5%) of the five-female PKS pools was also II-IN virus positive. Twenty-four blood smears from females were negative for EIBS inclusions (Appendix Table A-28). The fish at Wallowa did not receive erythromycin injections; one had clinical BKD (1.03 1 OD units), one had an OD reading of 0.721, one was at 0.547, two were in the 0.300-0.399 range, one had a reading of 0.123 and the remaining 18 were at 0.082 and below (Appendix Table A-26).

Carson spring chinook salmon adults at Lyons Ferry also provided eggs for the 95 brood year Umatilla production. These were sampled on 6 September 1995. Thirty-two individual OF and M samples were negative for replicating agents as were eight four-female PKS pools (Appendix Table A-25). Thirty-one kidneys from females had ELISA readings at or below 0.085 OD units and one was in the clinical range at 1.584 (Appendix Table A-23).

DISCUSSION

There was once again a total lack of ecroparasites and viral agents, including II-IN virus and EIBS, in fish reared at Umatilla Hatchery. Although bacterial types presumably capable of causing bacterial gill disease were isolated, no evidence for clinical gill disease has been observed, notwithstanding occasional aneurysms and isolated areas of hyperplastic filaments. The CWD bacterium, ***F. psychrophilus,*** was present in both populations of spring and fall chinook but no losses attributed to this disease were apparent.

Infectious hematopoietic necrosis virus was emphasized under Broodstock Monitoring because of the high prevalence (46.3%) of this agent in the Umatilla steelhead adults providing eggs for the 95 brood year, and because this is the first documented occurrence of the virus in steelhead at Minthom. Monitoring of this population annually since 1980 has shown IHN virus isolations only in adults held at Bonifer Springs in 1986 and at the Three Mile Falls Dam trapping facility in 1989 and 90 (infectious pancreatic necrosis virus was also isolated in 1986). Every spawned male and female adult at Minthom have been sampled and negative for MN virus since 1988. The 1995 Umatilla adults followed a trend towards high prevalences of IHN virus documented for spring chinook salmon adults in the Grande Ronde and Imnaha basins in 1993-95 and steelhead in 1995. A similar trend for adults was documented in the early 1980's when juvenile losses were widespread throughout the Columbia River basin (Groberg 1993); thus there is cause for concern. Indeed, in the spring of 1995 there was an epizootic of IHN in Imnaha spring chinook salmon smolts at Lookingglass Hatchery, the first ever at that facility. A highly virulent strain of MN virus for smolt age chinook salmon is also somewhat unusual and further cause for concern. Perhaps a basin-wide survey is again appropriate which incorporates new technologies for identifying genetic variants of the virus.

Erythromycin associated toxicity appears to be a common occurrence in the juvenile spring chinook salmon given this therapy at Umatilla Hatchery. It is not clear if this is more prevalent at Umatilla than other spring chinook facilities. Further investigation is needed in this area, particularly in light of the acute losses in the yearling fish during transfers to acclimation ponds in February of 1995. This episode certainly raises questions as to whether or not this was related to erythromycin and/or whether or not it was related to drawdown of the John Day pool. Did the handling simply eliminate those fish prone to toxicity or was a factor in the environment no longer present when attempts were made to reconstruct the loss?

The drawdown event could also be circumstantially related to morbidity and mortality in steelhead at both Umatilla and Irrigon Hatcheries. Irrigon reported acute loss and a mottled appearance in steelhead during handling one week earlier than when Umatilla reported steelhead with identical signs. Secondary fungal lesions were subsequently prevalent in steelhead at both locations with considerable mortality. No primary infectious agents were observed or detected in either case and some common environmental parameter was thus suspect. The logical common factor in this context is water, the chemistry of which may have been altered by the influence of the drawdown on the hydrology and chemistry of the hatcheries' well water. The alkalinity changes documented provide at least some minimal evidence to support this. If future John Day pool drawdowns are anticipated, enhanced water chemistry monitoring should be plan&d and implemented to address some of the questions raised by the events in February 1995 at Umatilla and Irrigon Hatcheries.

As BKD outbreaks occur it is possible to make some comparisons important in the evaluations for the rearing strategies at Umatilla Hatchery. Some of these comparisons focus on first pass and second pass (reuse) water between Oregon A (first pass) and B (second pass) raceways, and between Michigan

A (first pass), B (second pass) and C (third pass) raceways and the possible role that horizontal waterborne transmission of Rs may have between raceways. Upon comparing daily mortality rates between the 93 brood year spring chinook salmon programmed for fall release as subyearling or spring release as yearlings, a common pattern is evident. There were no differences in the daily mortality between A and B Michigan raceways in a series during the course of a BKD epizootic. Losses were relatively low in the 93 brood year fall release groups in A and B raceways when compared to the lower C raceways (Groberg et al. 1995): there were no fish in a comparable C raceway for the yearlings and BKD related losses were relatively low in the A and B raceways. For the 92 brood year fall release subyearlings, however, there were no differences in mortality rates between Michigan A, B and C raceways during the course of an episode of BKD (Groberg et al. 1995). Thus, there was a different pattern between different brood years under similar rearing strategies. This may relate to the degree of vertically transmitted Rs for a given brood year and which appears to have been greater for the 92 brood year (Keefe et al. 1994 and Groberg et al. 1995).

Among Oregon raceways of the spring chinook 93 brood year yearlings, the daily mortality rate was significantly lower in O4A than for the other three raceways (Figure 2). This raises the question of the probability of obtaining random distributions of these populations from a common pool, as clinical Rs infection levels among the fish in O4A were far less than in the other Oregon raceways, and O4A and 05A were intended to be replicates. The brood stock for the 93 brood year spring chinook salmon at Umatilla apparently had only a few females with high levels of Rs infection and this may have reduced the probably of obtaining equivalent groups. During the pre and early-BKD epizootic period, 15-30 September 1994 (Figure 2), there were significantly lower mortality rates in both O4A and 05A than in their corresponding B raceway. Mortality rates remained at a lower level throughout the epizootic in O4A and these rates were similar in 05A and B. The trend in higher mortality rates in Oregon B raceways during the pre and early-epizootic interval was also documented in the fall released subyearlings of this brood year (Groberg et al. 1995). This suggests there is a factor, somewhat subtle, operating in Oregon reuse raceways which predisposes fish in these raceways to an earlier onset of BKD than those in Oregon first pass raceways.

Statistical analysis of the preliberation ELISA data for the 93 brood year yearlings did reveal differences between the upper M5A Michigan raceway and the middle M5B raceway. This was the first opportunity to make comparisons of yearlings in Michigan raceways and the OD ranges and means were also indicative of differences (Appendix Table A-12). No attempts were made to compare Oregon and Michigan raceways using these data because they were different treatment groups based on erythromycin feeding protocols and they did not originate from a common population. Among the Oregon raceways of this stock, no significant differences in ELISA distributions were found (Appendix Table A-12). Why O4A was not different is somewhat confusing since it appeared to be less severely affected by Rs infections, at least in terms of clinical disease. A likely possibility is that clinical disease in O4A was from vertically transmitted Rs and these fish had died and were not represented in the grab-sampled preliberation samples. This also tends to contraindicate significant within-raceway horizontal transmission. Based on a single observation, there was an indication of Rs transmission "downstream" to a Michigan reuse raceway. As would be expected, this was manifested in yearling fish reared longer than fall released subyearlings. .Other than that, there is no strong statistical evidence from preliberation sampling for horizontal transmission to raceways using reuse water when data were analyzed from 92 and 93 brood year fall and spring released juvenile spring chinook salmon at Umatilla Hatchery. Horizontally transmitted secondary infections in yearlings may appear predominantly as higher ELISA distributions in downstream Michigan raceways and not as clinical disease prior to liberation. Long term survival data and ELISA analyses of returning adults relative to their raceway of rearing are needed to confirm this, along with more observations of yearling populations in Michigan raceways.

A third parameter by which BKD severity was assessed in the 93 brood year yearling spring chinook salmon is the prevalence of fish with clinical BKD out of the total morbidity and mortality examined during the entire range of monthly monitoring (Figure 1 and Table 1). By this criterion, significant differences were found between every upper A raceway and lower B raceway for both Oregon and Michigan raceways; in each case the lower raceway was significantly higher (given the lower severity of BKD in O4A this might have been expected in that series). Using the same parameters for comparison, no differences were seen between Oregon A and B raceways with 92 brood year yearlings. During an epizootic (Figures 2 and 3) the majority of fish examined have clinical BKD, whereas at other times this proportion is lower and moribund/fresh-dead fish are in the sample due to other conditions. There is a trend towards a higher proportion of clinical BKD mortality in lower B raceways during pre and early-epizootic periods (August-early October), although the sample sizes make such an analysis weak (Appendix Table A-9). This would tend to bias the proportion of clinical BKD fish towards the B raceways. The trend was more evident between M5A and M5B, which had received an earlier treatment of erythromycin, than for the 04 and 05 series which had not received any erythromycin. Indeed, higher mortality rates during the pre and early-epizootic period were verified in the 15-30 September interval in O4B and 05B discussed above. Possibly, this is a manifestation of higher stress levels in or horizontal transmission to these secondary raceways which exacerbates progression to clinical disease. Why this would not also be evident during epizootic conditions (mid-October and November) is unclear. Potentially, the progression to BKD at this time masks a more subtle stress-mediated or horizontally transmitted progression to a disease state. A combination of these two alternatives may also be operating simultaneously and both may be relatively subtle.

Erythromycin therapy in October-November 1994 did bring loss rates back to near-normal levels in the 93 brood year spring chinook yearlings. This was far more apparent in the Oregon raceways which were more severely affected. Mortality with clinical BKD, however, again began to increase in early January when another scheduled pre-release treatment was given, and again, mortality rates declined. Then, in the days prior to liberation in late February, there was a trend towards elevated BKD mortality. A disturbing pattern thus emerges, indicating that Rs infections were quite severe in these populations of spring chinook salmon and antibiotic therapy was simply suppressing progression to disease, which could proceed uninhibited during the remainder of their free-ranging life cycle.

A review of the ELISA data for Carson spring chinook salmon adults reveals that the females sampled in 1992 had substantial bacterial kidney disease and Rs infections (Keefe et al. 1994) when compared to those sampled in 1993 when infection levels and prevalences appeared to be very low (Groberg et al. 1995). These were subsamples of the total population spawned for Umatilla production and because of the BKD in the 93 brood year juveniles it would seem that at least some females were heavily infected with Rs. Otherwise, it is difficult to account for the BKD in these juveniles. These differences in Rs infection levels and prevalences among brood stocks will undoubtedly translate to different outcomes during rearing of their progeny, Thus comparisons between brood years will be inherently complicated.

A variety of confounding factors particularly relevant to analyzing the dynamics of Rs infection at Umatilla have been identified during the course of the fish health monitoring project. Some of these relate to conducting “experiments” at a production facility and others relate to the complex host-pathogen interaction between salmonid hosts and the Rs bacterium. The problem in establishing replicates was apparent in the disparity of BKD severity between the O4A and 05A raceways of 93 brood year spring chinook salmon programmed as yearlings: these were intended to be replicates. This is especially problematic when attempting to make evaluations with a vertically transmitted pathogen. Of this same stock, fish in Michigan raceways were essentially different treatment groups in terms of their incubation, ponding strategy and previous antibiotic treatment than those in Oregon raceways, thus many evaluations were not valid. That these fish represented two different populations was evident from the relative severity of BKD between them. Where the Rs pathogen-salmonid host interaction is concerned, the dynamics of vertical and horizontal transmission are likely being manifested simultaneously and with different intensities among different raceway configurations. Analyses directed at horizontal transmission are therefore difficult. Ideally, brood stock that are Rs negative or harbor the bacterium at very low levels would be used. This is not to say that these evaluations are not appropriate and informative; quite the contrary, each year has produced a valuable learning experience and better analyses can be made to evaluate the Umatilla program, with the ultimate goal of enhanced fish health.

ACKNOWLEDGMENTS

Valuable assistance has been provided by the Umatilla Hatchery crew, the ODFW Research and Development staff in Herrniston, and ODFW Fish Pathology personnel in Clackamas and Corvallis. Appreciation is extended to Washington Department of Fish and Wildlife personnel at Priest Rapids and Lyons Ferry Hatcheries for their cooperation.

LITERATURE CITED

Faler, J. C. and C. M. Moffitt. 1993. Toxicity of erythromycin to juvenile spring chinook salmon. Pages 64-74 *in* H. E. Fomer, Jr., editor. Proceedings of the Forty-Fourth Annual Northwest Fish Culture Conference. Spokane, Washington.

Groberg, W. J., Jr. 1983. The status of viral fish diseases in the Columbia River basin. Pages l-22 *in* J. C. Leong and T. Y. Barila, editors. Proceedings: Workshop on viral diseases of salmonid fishes in the Columbia River basin. Bonneville Power Administration, Portland, Oregon.

Groberg, W. J., Jr., N. L. Hurtado, S. T. Onjukka and K. Waln. 1994. Lack of evidence for horizontal transmission of *Renibacterium salmoninarum*, the causative agent of bacterial kidney disease, among raceways of juvenile spring chinook salmon reared at Umatilla Hatchery. *In* Proceedings of the 45th Annual Northwest Fish Culture Conference. Sunriver. Oregon.

Groberg, W. J., Jr., N. L. Hurtado, S. T. Onjukka and K. Waln. 1995. Umatilla Hatchery monitoring and evaluation: Fish health monitoring and evaluation. Annual Report for Project Number 90-005. Bonneville Power Administration, Portland, Oregon.

Keefe, M. L., R. W. Carmichael, R. A. French, W. J. Groberg and M. C. Hayes. 1993. Umatilla Hatchery monitoring and evaluation. Annual Report for Project Number 90-005. Bonneville Power Administration, Portland, Oregon.

Keefe, M. L., R. W. Carmichael, S. M. Focher, W. J. Groberg and M. C. Hayes. 1994 Umatilla Hatchery monitoring and evaluation. Annual Report for Project Number 90-005. Bonneville Power Administration, Portland, Oregon.

Ott, L. 1977. An introduction to statistical methods and data analysis. Duxbury Press, North Scituate, Massachusetts.

Triola, M. F. 1992. Elementary Statistics. Addison-Wesley Publishing Company, Reading, Massachusetts.

Waln, K., S. T. Onjukka and W. J. Groberg, Jr. 1995. Statistical comparisons of thirty-fish sample size groups for *Renibacterium salmoninarum* antigen by the enzyme-linked immunosorbent assay. *In* Proceedings of the 1995 Western Fish Disease Conference. Twin Falls, Idaho.

APPENDIX A

Appendix Table A-l. Number of 94 brood year Umatilla summer steelhead juveniles sampled per raceway in two Oregon raceways (03A and 03B) and three Michigan raceways (M8A, M8B and M8C) during monthly monitoring.

Date sampled	O3A[1]	O3A[2]	O3B[1]	O3B[2]	M8A[1]	M8A[2]	M8B[1]	M8C[1]	M8C[2]
08-94	5	5							
09-94	5	5							
10-94	4		5	5					
1 l-94					2		0		5
12-94					3		0	2	5
01-95					5		5	5	5
02-95					***0***		***0***	5	5
03-95					5	5			

1 ***Moribund or fresh-dead fish.***
2 ***Normal, healthy appearing fish.***

Appendix Table A-2. Number of 94 brood year Priest Rapids chinook salmon juveniles, released as subyearlings, sampled per raceway in Oregon series 02 (02A and 028) and Michigan series M2 and M3 (M2A, M2B, M2C, M3A, M3B and M3C) during monthly monitoring.

Date sampled	O2A[1]	O2B[1]	O2B[2]	M2A[1]	M2B[1]	M2C[1]	M2C[2]	M3A[1]	M3B[1]	M3C[1]	M3C[2]
04-95	3	5	5	5	5	5	5	0[3]	5	5	5

1 *Moribund or fresh-dead fish.*
2 *Normal, healthy appearing fish.*
3 *Codewire ragging and clipping in this raceway during monthly morritoring, no normal mortality.*

Appendix Table A-3. Number of 93 brood year Carson spring chinook salmon juveniles, released as yearlings, sampled per raceway in Oregon series 4 and 5 (O4A, O4B, O5A and O5B) and Michigan series (M5A and M5B) during monthly monitoring.

Date sampled	O4A[1]	O4A[2]	O4B[1]	O4B[2]	O5A[1]	O5A[2]	O5B[1]	O5B[2]	M5A[1]	M5B[1]	M5B[2]
04-94	5	5									
05-94	5	5			5	5					
06-94	5	5			5	5					
07-94					5	5			5	5	5
08-94	5		5	5	5		5	5	5	5	5
09-94	5'		5	5	5		5	5	5	5	5
10-94	5		5	5	5		5	5	5	5	5
11-94	2		1	5	5		4	5	0	1	5
12-94	5		5	5	5		5	5	5	5	5
01-95	2		5	5	4		4	5	5	5	5

[1] *Moribund or fresh-dead fish.*
[2] *Normal, healthy appearing fish.*

Appendix Table A-4. Proportions and prevalences (%) of bacterial agents isolated from moribund or fresh-dead 94 brood year Umatilla summer steelhead during monthly juvenile fish health monitoring.

Date sampled	Raceway	Systemic bacterial		Gill bacteria2
		F. psychrophilus	***APS***	
08-94	03A	0/5 *(0%)*	4/5 ***(80%)***	1/5 (20%)
09-94	03A	0/5 *(0%)*	2/5 *(40%)*	ND3
lo-94	03A	0/4 *(0%)*	0/4 *(0%)*	0/3 ***(0%)***
	03B	0/5 *(0%)*	4/5 ***(80%)***	***ND3***
11-94	**M8A**	0/2 *(0%)*	0/2 *(0%)*	1/2 (50%)
12-94	**M8A**	0/3 *(0%)*	0/3 *(0%)*	ND[3]
	M8B	ND3	ND3	ND[3]
	M8C	0/2 *(0%)*	on (0%)	0/1 (0%)
01-95	**M8A**	0/5 *(0%)*	4/5 ***(80%)***	ND[3]
	M8B	0/5 *(0%)*	4/5 ***(80%)***	0/1 (0%)
	M8C	0/5 *(0%)*	2/5 ***(40%)***	0/1 (0%)
02-95	**M8A**	ND[3]	ND[3]	ND[3]
	M8B	ND3	ND[3]	ND[3]
	M8C	0/4 (0%)	0/4 **(0%)**	3/4 ***(75%)***
03-95	**M8A**	0/5 *(0%)*	0/5 *(0%)*	1/5 (20%)

1 ***The only systemic bacteria isolated from kidney smear inocula were*** Flexibacter psychrophilus ***and aeromonad-pseudomonad (APS) types.***

2 *These were **determined** to be significant **only if yellow** pigmented colonies were the **prevalent type on smears made from gill inocula.***

3 ***Indicates not done (ND) because no moribund or fresh-dead fish were available.***

Appendix Table A-5. Proportions and prevalences (%) of bacterial agents isolated from moribund or fresh-dead 94 brood year Priest Rapids fall chinook salmon, released as subyearlings, during monthly juvenile fish health monitoring.

		Systemic Bacterial		Gill Bacteria*
Date sampled	Raceway	*F. psychrophilus*	*APS*	
04-05-95	02A	0/3 (0%)	1/3 (33%)	0/3 (0%)
	02B	0/5 (0%)	4/5 (80%)	0/5 (0%)
	M2A	0/5 (0%)	2/5 (40%)	0/5 (0%)
	M2B	0/5 (0%)	3/5 (60%)	1/5 (20%)
	M2C	3/5 (60%)[3]	5/5 (100%)	3/5 (60%)
	M3A	ND[4]	ND[4]	ND[4]
	M3B	3/5 (60%)[3]	3/5 (60%)[3]	5/5 (100%)[3]
	M3C	1/5 (20%)[3]	1/5 (20%)[3]	3/5 (60%)[3]

1 *The only systemic bacteria isolatedfrom* kidney *smear inocula* were Flexibacter psychrophilus *and aeromonad-pseudomonad (APS) types.*
2 *These were determined to be significant only if yellow pigmented colonies were the prevalent type on smears made from gill inocula.*
3 Flexibacter psychrophilus *was identified by differentially culturing yellow pigmented isolates at 18°C and at 30°C. Three of nine isolates were were identified* as Flexibacter psychrophilus *when growth occurred only at 18°C.*
4 *Indicates not done (ND) because no moribund or fresh-dead fish were available.*

Appendix Table A-6. Proportions and prevalences (%) of bacterial agents isolated from moribund or freshdead 93 brood year Carson spring chinook salmon. released as yearlings, during monthly juvenile fish health monitoring.

		Systemic bacterial		Gill bacteria[2]
Date Sampled	Raceway	*F. psychrophilus*	*APS*	
04-94	O4A	0/5 (0%)	0/5 (0%)	0/4 (0%)
05-94	O4A	0/5 (0%)	1/5 (20%)	0/5 (0%)
	05A	0/5 (0%)	1/5 (20%)	0/5 (0%)
06-94	O4A	0/5 (0%)	0/5 (0%)	0/5 (0%)
	05A	0/5 (0%)	0/5 (0%)	0/5 (0%)
07-94	05A	0/5 (0%)	0/5 (0%)	0/5 (0%)
	M5A	0/5 (0%)	0/5 (0%)	0/3 (0%)
	M5B	0/5 (0%)	2/5 (40%)	0/1 (0%)
08-94	O4A	0/5 *(0%)*	2/5 (40%)	0/2 (0%)
	O4B	0/5 (0%)	4/5 (80%)	0/5 (0%)
	05A	1/5 (20%)	2/5 (40%)	0/5 (0%)
	05B	1/5 (20%)	3/5 (60%)	3/3 (100%)
	M5A	1/5 (20%)	3/5 (60%)	0/2 (0%)
	M5B	0/5 (0%)	2/5 (40%)	0/2 (0%)
09-94	# A	0/5 (0%)	0/5 *(0%)*	0/1 (0%)
	O4B	0/5 (0%)	1/5 (20%)	0/1 (0%)
	05A	0/5 (0%)	0/5 (0%)	0/5 (0%)
	05B	0/5 (0%)	4/5 (80%)	0/1 (0%)
	M5A	0/5 (0%)	0/5 (0%)	0/1 (0%)
	M5B	0/5 (0%)	0/5 (0%)	ND3

1 *The only systemic bacteria isolated from kidney smear inocula were aeromonad-pseudomonad (APS) types.*

2 *These were determined to be significant only if yellow pigmented colonies were the prevalent type on smears made from gill inocula.*

3 *Indicates not done (ND) because no moribund or fresh-dead fish were available.*

Appendix Table A-6. Continued.

Date Sampled	Raceway	Systemic bacterial		Gill bacteria[2]
		F. psychrophilus	*APS*	
10-94	O4A	0/5 (0%)	2/5 (40%)	1/5 (20%)
	O4B	0/5 (0%)	2/5 (40%)	0/3 (0%)
	05A	0/5 (0%)	0/5 (0%)	1/5 (20%)
	05B	0/5 (0%)	0/5 (0%)	0/5 (0%)
	M5A	0/5 (0%)	4/5 (80%)	0/5 (0%)
	M5B	0/5 (0%)	1/5 (20%)	0/2 (0%)
1 l-94	O4A	012 (0%)	012 (0%)	0/2 (0%)
	O4B	0/1 (0%)	0/1 (0%)	0/1 (0%)
	05A	0/5 (0%)	3/5 (60%)	0/3 (0%)
	05B	0/4 (0%)	1/4 (25%)	0/3 (0%)
	M5A	ND3	ND3	ND3
	M5B	0/1 (0%)	O/l (0%)	O/l (0%)
12-94	O4A	0/5 (0%)	0/5 (0%)	0/3 (0%)
	O4B	0/5 (0%)	1/5 (20%)	0/5 (0%)
	05A	0/5 (0%)	0/5 (0%)	0/2 (0%)
	05B	0/5 (0%)	4/5 (80%)	0/1 (0%)
	M5A	0/5 (0%)	0/5 (0%)	0/2 (0%)
	M5B	0/5 (0%)	0/5 (0%)	2/2 (100%)
01-95	O4A	0/2 (0%)	0/2 (0%)	ND[3]
	O4B	0/5 (0%)	4/5 (80%)	0/2 (0%)
	05A	014 (0%)	114 (25%)	ND[3]
	05B	0/4 (0%)	1/4 (25 %)	0/2 (0%)
	M5A	0/5 (0%)	1/5 (20%)	0/2 (0%)
	M5B	0/5 (0%)	1/5 (20%)	0/2 (0%)

Appendix Table A-7. DFAT results and ELISA readings (OD_{405}) of kidney samples[1] from 94 brood year Umatilla summer steelhead juveniles sampled during monthly monitoring from Oregon raceways 03A and 03B and Michigan raceways M8A, M8B and M8C.

Date sampled	ELISA OD_{405}							
	O3A[2]	O3B[2]	O3B[3]	M8A[2]	M8A[3]	M8B[2]	M8C[2]	M8C[3]
08-94	0/5[4]	0/5[4]						
09-94	.013	.011						
	.018	.015						
	.019	.023						
	.020	.032						
	.039	.077						
10-94	.137	0/5[4]	.016					
	.176		.040					
	.318		.183					
	.412		.362					
			.538					
11-94				.003				.011
				.006				.011
								.015
								.019
								.019
12-94				.005			.002	.001
				.005			.006	.002
				.007				.004
								.005
								.007
01-95				.011		.012	.011	.021
				.015		.015	.014	.041
				.017		.040	.016	.120
				.033		.045	.040	.153
				.113		.183	.176	.306

1 *Individual kidney samples were homogenized in PBS-Tween 20 buffer at a I :7 or I :I5 weight/volume dilution for the ELISA.*

2 *Moribund or fresh-dead fish.*

3 *Normal, healthy appearing fish.*

4 *Examined by the DFAT because of the small fish size.*

Appendix Table A-7. Continued.

Date sampled	ELISA OD_{405}							
	$O3A^2$	$O3B^2$	$O3B^3$	$M8A^2$	$M8A^3$	$M8B^2$	$M8C^2$	$M8C^3$
02-95							.008	.007
							.008	.011
							.008	.018
							.010	.028
							.011	.100
03-95				.007	.007			
				.010	.009			
				.011	.014			
				.011	.032			
				.011	.035			

Appendix Table A-8. Proportion of 94 brood year Priest Rapids fall chinook salmon juveniles, released as subyearlings, positive by the DFAT for ***Renibacterium salmoninarum*** during monthly monitoring from Oregon raceways 02A and 02B and Michigan series M2 and M3 **(M2A, M2B, M2C, M3A, M3B** and **M3C)**.

	Raceway									
Date sampled	**O2A**[1]	**O2B**[1]	**O2B**[2]	**M2A**[1]	**M2B**[1]	**M2C**[1]	**M2C**[2]	**M3B**[1]	**M3C**[1]	**M3C**[2]
04-95	0/3	0/5	0/5	0/5	0/5	0/5	0/5	0/5	0/5	0/5

1 ***Moribund or fresh-dead fish.***
2 ***Normal, healthy-appearing fish.***

Appendix Table A-9. DFAT results and ELISA readings (OD_{405}) for ***Renibacterium safmoninarum*** of kidney samples[1] from 93 brood year Carson spring chinook salmon juveniles, released as yearlings, sampled during monthly monitoring from four Oregon raceways (O4A, O4B, O5A and 05B) and two Michigan raceways (M5A and M5B).

	ELISA OD_{405}										
Date sampled	O4A[2]	O4A[3]	O4B[2]	O4B[3]	O5A[2]	O5A[3]	O5B[2]	O5B[3]	M5A[2]	M5B[2]	M5B[3]
04-94	0/5[4]	0/5[4]									
05-94	.006	.009			0/5[4]	0/5[4]					
	.009	.010									
	.012	.011									
	.015	.011									
	.041	.016									
06-94	.008	.010			.011	.008					
	.008	.013			.013	.011					
	.010	.017			.013	.017					
	.021	.033			.028	.020					
	.021	.033			.029	.022					

1 ***Individual kidney samples were homogenized in PBS-Tween 20 buffer at a 1:7 or 1:15 weight/volume dilution*** *for* ***the ELISA.***
2 ***Moribund or fresh-dead fish.***
3 ***Normal, healthy appearing fish.***
4 ***Examined by DFAT because*** *of small* ***fish*** *size.*

Appendix Table A-9. Continued.

Date sampled	ELISA OD_{405}										
	O4A[2]	O4A[3]	O4B[2]	O4B[3]	O5A[2]	O5A[3]	O5B[2]	O5B[3]	M5A[2]	M5B[2]	M5B[3]
07-94					.012	.013			.007	.001	.007
					.013	.014			.007	.009	.013
					.014	.015			.010	.011	.014
					.037	.020			.012	.016	.030
					.045	.029			.020	.055	.035
08-94	.004		.009	.006	.016		.019	.034	.008	.003	.004
	.009		.043	.026	.019		2.665	.037	.009	.016	.005
	.045		2.363	.029	.039		2.766	.038	.009	.416	.025
	2.518		2.561	.105	2.722		2.918	.045	.028	2.506	.028
	2.582		2.563	.117	3.022		2.969	.266	.065	2.517	.051
09-94	.018		.032	.017	.021		.024	.019	.018	.198	.013
	.027		.063	.017	.384		.063	.020	.051	.255	.014
	.232		2.277	.031	2.674		2.565	.028	.420	1.763	.069
	2.732		2.640	.057	2.732		2.739	.263	2.629	2.621	.094
	2.848		2.714	.095	2.783		2.935	1.688	2.751	2.768	.819

Appendix Table A-9. Continued.

	ELISA OD_{405}										
Date sampled	O4A[2]	O4A[3]	O4B[2]	O4B[3]	O5A[2]	O5A[3]	O5B[2]	O5B[3]	M5A[2]	M5B[2]	M5B[3]
10-94	.039		.035	.030	2.461		2.481	.023	.104	1.534	.072
	.085		.728	.059	2.669		2.667	.029	.154	2.476	.304
	2.704		1.410	.070	2.774		2.831	.049	2.618	2.585	.590
	2.732		2.697	.141	2.843		2.886	.115	2.712	2.746	.892
	2.945		2.923	1.716	2.920		2.989	1.691	2.861	2.839	2.683
11-94	.012		.088	.013	.162		.043	.020		.033	.020
	.068			.014	.184		.057	.026			.020
				.014	.430		1.567	.027			.029
				.019	.513		3.133	.027			.032
				.023	3.003			.028			.044
12-94	.020		.042	.020	.194		.192	.022	.024	2.170	.011
	.026		.051	.020	1.287		2.547	.034	.047	2.533	.013
	2.689		1.509	.023	2.177		2.575	.039	1.258	2.692	.018
	2.760		2.255	.029	3.009		2.785	.050	2.131	2.893	.027
	2.773		2.688	.173	3.013		2.886	.062	2.613	2.929	.267
01-95	.214		.609	.132	1.813		.298	.036	.013	.102	.029
	2.944		2.507	.270	2.541		1.769	.051	.105	2.550	.031
			2.760	.297	3.024		2.839	.059	2.848	2.748	.104
			2.770	.332	3.060		2.954	.063	2.851	2.909	.132
			2.944	.611				.131	2.944	2.940	.133

Appendix Table A-10. Preliberation ELISA readings (OD_{405}) for ***Renibacterium salmoninarum*** of kidney samples[1] from 30 Umatilla 94 brood year summer steelhead juveniles from each of three Michigan raceways (M8A, M8B and M8C). Means and ranges for each raceway are shown below the 30 individual sample readings. Fish in M8B and M8C were sampled on 03-08-95 at a mean body weight of 78.3 gms/fish. M8A was sampled on 04-08-95 at a mean body weight of 85.7 gms/fish.

Sample number	ELISA OD_{405} M8A	M8B	M8C
01	.002	.004	.005
02	.006	.004	.005
03	.006	.004	.006
04	.006	.004	.006
05	.006	.006	.006
06	.007	.006	.006
07	.008	.006	.007
08	.008	.006	.007
09	.008	.006	.007
10	.009	.006	.008
11	.009	.006	.008
12	.009	.008	.008
13	.009	.008	.009
14	.010	.008	.009
15	.010	.008	.012
16	.010	.008	.012
17	.010	.008	.013
18	.011	.009	.013
19	.011	.009	.013
20	.011	.009	.013
21	.011	.009	.014
22	.011	.010	.015
23	.012	.010	.016
24	.012	.010	.016
25	.015	.011	.017
26	.016	.012	.017
27	.018	.012	.018
28	.028	.012	.018
29	.032	.016	.021
30	.040	.026	.029
Mean	.012	.009	.012
Range	.002-.040	.004-.026	.005-.029

[1] ***Individual kidney samples were homogenized in PBS-Tween 20 buffer at a 1:7 weight/volume dilution.***

Appendix Table A-l 1. Preliberation ELISA readings (OD_{405}) for ***Renibacterium salmoninarum*** of kidney samples[1] from 30 Priest Rapids 94 brood year fall chinook salmon juveniles, released as subyearlings, from each of four Oregon raceways (O1A, O1B, 03A and 03B) and six Michigan raceways (M2.4, M2B, M2C, M3A, M3B and M3C). Means and ranges for each raceway are shown below the 30 individual sample readings. Fish in four Oregon and six Michigan raceways were sampled on 05-11-95 at mean body weights of 6.7 and 6.4 gms/fish, respectively.

	ELISA OD_{405}									
Sample number	O1A	O1B	03A	03B	M2A	M2B	M2C	M3A	M3B	M3C
01	.010	.009	.010	.004	.006	.005	.011	.008	.010	.008
02	.014	.009	.011	.012	.009	.006	.012	.008	.016	.009
03	.015	.011	.011	.012	.009	.008	.012	.008	.016	.011
04	.017	.012	.011	.012	.009	.009	.013	.009	.017	.012
05	.017	.012	.013	.013	.011	.009	.016	.010	.017	.014
06	.018	.013	.013	.013	.011	.009	.016	.010	.017	.015
07	.019	.014	.014	.015	.011	.010	.016	.010	.018	.015
08	.020	.015	.014	.016	.011	.012	.017	.010	.019	.016
09	.020	.016	.014	.018	.011	.013	.017	.011	.019	.017
10	.021	.018	.014	.018	.014	.013	.017	.012	.020	.017
11	.022	.018	.015	.018	.014	.013	.017	.012	.021	.018
12	.023	.018	.015	.018	.014	.013	.018	.013	.021	.018
13	.024	.019	.016	.019	.015	.013	.019	.013	.023	.018
14	.026	.020	.016	.019	.015	.014	.020	.015	.023	.020
15	.029	.020	.017	.019	.016	.014	.020	.015	.024	.021
16	.031	.021	.018	.020	.017	.014	.021	.016	.025	.022
17	.032	.021	.018	.020	.017	.015	.021	.018	.026	.022
18	.036	.021	.019	.022	.017	.015	.023	.019	.026	.023
19	.036	.021	.020	.022	.021	.016	.025	.020	.026	.024
20	.037	.022	.022	.023	.022	.017	.025	.022	.027	.025

1 *Individual kidney samples were homogenized in PBS-Tween 20 buffer at 1:15 weight/volume dilution.*

Appendix Table A-l 1. Continued.

Sample number	ELISA OD_{405}									
	O1A	O1B	03A	03B	M2A	M2B	M2C	M3A	M3B	M3C
21	.041	.023	.024	.023	.022	.018	.026	.023	.028	.028
22	.043	.023	.024	.023	.024	.020	.026	.023	.029	.031
23	.048	.025	.025	.025	.024	.020	.027	.026	.031	.034
24	.059	.026	.025	.026	.025	.020	.028	.026	.031	.035
25	.073	.027	.027	.027	.027	.020	.028	.028	.032	.036
26	.085	.027	.027	.028	.031	.022	.032	.028	.036	.041
27	.089	.028	.028	.032	.034	.022	.032	.031	.040	.042
28	.095	.030	.031	.036	.048	.023	.045	.034	.051	.044
29	.112	.044	.047	.037	.048	.024	.051	.035	.051	.047
30	.133	.069	.048	.037	.056	.026	.058	.054	.104	.053
Mean	.042	.022	.020	.021	.020	.015	.024	.019	.028	.025
Range	.010-.133	.009-.069	.010-.048	.004-.037	.006-.056	.005-.026	.011-.058	.008-.054	.010-.104	.008-.053

Appendix Table A-12. Preliberation ELISA readings (OD_{405}) for ***Renibacterium salmoninarum*** of kidney **samples**[1] from 30 Carson 93 brood year spring chinook salmon juveniles, released as yearlings, from each of four Oregon raceways (**O4A, 04B,** 05A and 05B) and two Michigan raceways (**M5A** and **M5B**). Means and ranges for each raceway are shown below the 30 individual sample readings. Fish were sampled on 02-07-95 from Oregon and Michigan series at mean body weights of 52.2 **gms/fish** and 55.0 **gms/fish,** respectively.

Sample number	ELISA OD_{405}					
	O4A	**O4B**	05A	05B	**M5A**	**M5B**
01	.010	.009	.006	.010	.005	.011
02	.012	.010	.012	.014	.006	.013
03	.012	.014	.012	.017	.006	.013
04	.013	.015	.013	.022	.006	.013
05	.014	.015	.014	.023	.007	.014
06	.016	.015	.014	.024	.008	.015
07	.017	.017	.014	.024	.008	.016
08	.020	.017	.015	.025	.009	.016
09	.020	.017	.015	.028	.009	.016
10	.021	.017	.015	.030	.010	.016
11	.022	.017	.016	.031	.011	.017
12	.024	.018	.016	.034	.011	.017
13	.025	.018	.017	.034	.012	.018
14	.025	.019	.018	.035	.016	.019
15	.026	.019	.020	.035	.017	.022
16	.028	.020	.023	.037	.017	.024
17	.031	.020	.028	.037	.019	.028
18	.033	.022	.031	.037	.020	.031
19	.034	.023	.038	.038	.021	.032
20	.036	.025	.039	.038	.024	.036
21	.039	.027	.047	.039	.025	.037
22	.046	.028	.070	.049	.027	.038
23	.049	.029	.082	.055	.028	.038
24	.049	.031	.124	.068	.029	.043
25	.071	.032	.127	.088	.029	.049
26	.114	.034	.222	.094	.030	.053
27	.120	.035	.296	.272	.035	.094
28	.144	.056	.436	.285	.050	.267
29	.229	.217	1.690	.422	.080	.370
30	.268	.439	2.303	.528	.100	1.169
Mean	.052	.043	.192	.082	.023	.085
Range	.010-.268	.009-.439	.006-2.303	.010-.528	.005-.100	.011-1.169

1 ***Individual kidney samples were homogenized in PBS-Tween 20 buffer at a 1:7 weight/volume dilution.***

Appendix Table A-13. Preliberation ELISA readings (OD_{405}) for ***Renibacterium salmoninarum*** of kidney samples[1] from 120 Carson 93 brood year spring chinook salmon juveniles, released as yearlings, from seven raceways at Bonneville Hatchery. Means and ranges for each raceway are shown below the individual sample readings. Fish from B4 and B5 were sampled on 02-15-95 and fish from B1, B2, B3, B7 and B8 were sampled on 03-22-95 at mean body weights of 32.4 gms/fish and 33.6 gms/fish, respectively.

Sample number	ELISA OD_{405}						
	B1	B2	B3	B4	B5	B7	B8
01	.008	.027	.008	.012	.011	.012	.008
02	.014	.028	.014	.015	.012	.013	.010
03	.015	.028	.016	.016	.016	.015	.010
04	.018	.029	.018	.016	.016	.015	.011
05	.018	.029	.019	.016	.017	.016	.014
06	.019	.030	.022	.018	.018	.017	.014
07	.020	.031	.022	.018	.020	.017	.015
08	.023	.033	.024	.019	.020	.018	.015
09	.030	.041	.040	.020	.023	.019	.024
IO	.030	.043	.058	.021	.023	.019	.028
11	.030	.047	.060	.021	.025	.025	.028
12	.035	.080	.064	.023	.025	.036	.036
13				.023	.025		
14				.023	.026		
15				.024	.027		
16				.024	.028		
17				.026	.030		
18				.026	.031		
19				.026	.031		
20				.027	.032		
21				.028	.032		
22				.029	.033		
23				.036	.035		
24				.037	.039		
25				.043	.042		
26				.044	.044		
27				.047	.045		
28				.061	.046		
29				.065	.047		
30				.068	.056		
Mean	.022	.037	.030	.029	.029	.019	.018
Range	.008-.035	.027-.080	.008-.064	.012-.068	.011-.056	.012-.036	.008-.036

[1] ***Individual kidney samples were homogenized in PBS-Tween 20 buffer at a 1:7 weight/volume dilution.***

Appendix Table A-14. ELISA readings (OD_{405}) for ***Renibacterium salmoninarum*** of kidney **samples**[1] from 65 Umatilla summer steelhead adults spawned in 1995 for Umatilla Hatchery 95 brood year production.

Sample number	ELISA OD_{405}	Sample number	ELISA OD_{405}	Sample number	ELISA OD_{405}
01	.012	26	.032	51	.068
02	.015	27	.032	52	.069
03	.016	28	.033	53	.073
04	.019	29	.033	54	.084
05	.020	30	.034	55	.085
06	.020	31	.034	56	.086
07	.020	32	.035	57	.091
08	.021	33	.035	58	.103
09	.022	34	.035	59	.104
10	.023	35	.036	60	.116
11	.024	36	.037	61	.125
12	.024	37	.037	62	.126
13	.026	38	.039	63	.144
14	.026	39	.039	64	.349
15	.027	40	.041	65	3.056
16	.027	41	.041		
17	.029	42	.042		
18	.029	43	.042		
19	.030	44	.042		
20	.030	45	.043		
21	.030	46	.043		
22	.030	47	.049		
23	.031	48	.053		
24	.031	49	.058		
25	.031	50	.060		

1 ***Individual kidney samples were homogenized in PBS-Tween 20 buffer at a 1:3 weight/volume dilution.***

Appendix Table A-15. ELISA readings (OD_{405}) for ***Renibacterium salmoninarum*** of kidney samples1 from 39 Umatilla summer steelhead adult mortalities in 1995.

Sample number	ELISA OD_{405}	Sample number	ELISA OD_{405}
01	.021	21	.042
02	.021	22	.046
03	.022	23	.047
04	.023	24	.048
05	.023	25	.049
06	.024	26	.057
07	.027	27	.065
08	.028	28	.070
09	.034	29	.070
10	.035	30	.071
11	.035	31	.081
12	.035	32	.082
13	.037	33	.083
14	.037	34	.089
15	.037	35	.089
16	.038	36	.091
17	.039	37	.095
18	.039	38	.125
19	.042	39	.152
20	.042		

[1] ***Individual kidney samples were homogenized in PBS-Tween 20 buffer at a 1:3 weight/volume dilution.***

Appendix Table A-16. Proportions and prevalences (%) of infectious hematopoietic necrosis virus (IHNV) detected in individual ovarian fluid (OF) and milt (M) samples, and three-fish pooled pyloric caeca/kidney/spleen (PKS) samples from. Umatilla summer steelhead spawned in 1995 at Minthorn for Umatilla Hatchery 95 brood year production.

Date sampled	Proportion and prevalence (%) of IHNV		
	OF	M	PKS
03-29-95	0/6 (0%)	0/6 (0%)	0/4 (0%)
04-05-95	0/4 (0%)	0/4 (0%)	2/4 (50%)[1]
04-12-95	0/4 (0%)	0/4 (0%)	0/4 (0%)
04-19-95	5/7 (71.4%)	2/7 (29%)	3/6 (50%)
04-26-95	3/4 (75%)	0/4 (0%)	1/4 (25%)
05-03-95	6/8 (75%)	5/8 (63%)	2/3 (66.6%)
05-10-95	3/3 (100%)	0/3 (0%)	1/1 (100%)
05-17-95	0/3 (0%)	0/3 (0%)	1/3 (33.3%)
05-24-95	2/2 (100%)	0/1 (0%)	1/2 (50%)
Total	19/41 (46.3%)	7/40 (17.5%)	11/31 (35.5%)

[1] *Both IHNV isolates from this group were determined to be a Type 2 strain in the indirect fluorescent antibody test using strain-specific 105B monoclonal antibody.*

Appendix Table A-17. ELISA readings (OD_{405}) for ***Renibacterium salmoninarum*** of 40 kidney samples[1] from Priest Rapids fall chinook salmon females spawned in 1994 for Umatilla Hatchery 94 brood year production.

Date sampled	ELISA OD_{405}	Date sampled	ELISA OD_{405}
1 l-lo-94	.004	11-14-94	.003
	.006		.003
	.011		.004
	.011		.005
	.011		.005
	.012		.005
	.012		.006
	.013		.007
	.013		.008
	.013		.008
	.013		.009
	.014		.010
	.014		.010
	.014		.011
	.016		.012
	.018		.015
	.021		.056
	.029		.062
	.133		.106
	.246		.123
Mean	.031		.023
Range	.004-.246		.003-.123

[1] ***Individual kidney samples were homogenized in PBS-Tween 20 buffer at a 1:3 weight/volume dilution.***

Appendix Table A-18. Date and number of spawned adults sampled for culturable viruses from Priest Rapids fall chinook salmon spawned in 1994 for Umatilla Hatchery 94 brood year production. Culturable viruses were sampled for as three **fish** pools for ovarian fluids (OF) from females, three fish pools for milt samples from males (M) and five-fish pyloric **caeca/kidney/spleen** (PKS) pools from females.

Date sampled	Number and type of sample for culturable viruses		
	OF	M	PKS
1 l-lo-94	20	20	12
11-14-94	20	20	

Appendix Table A-19. Date and number of spawned females sampled for erythrocytic inclusion body syndrome **(EIBS)** during spawning of Priest Rapids fall chinook salmon spawned in 1994 for Umatilla Hatchery 94 brood year production.

Date sampled	Number of **fish** sampled
1 l-lo-94	**20**
11-14-94	20

Appendix Table A-20. ELISA readings (OD_{405}) for ***Renibacterium salmoninarum*** of 71 kidney **samples**[1] from Carson spring chinook salmon females spawned at Lyons Ferry Hatchery in 1994 for Umatilla Hatchery 94 brood year production.

Date sampled	ELISA OD_{405}	Date sampled	ELISA OD_{405}
08-24-94	.015	09-07-94	.014
	.017		.015
	.017		.015
	.023		.015
	.023		.016
	.025		.017
	.025		.020
	.026		.022
	.026		.023
	.026		.023
	.028		.023
	.030		.024
	.038		.026
	.520		.027
			.028
08-3 l-94	.006		.029
	.007		.035
	.011		.036
	.012		.042
	.013		.042
	.013		
	.015	09-14-94	.011
	.015		.011
	.017		.013
	.018		.014
	.018		.014
	.020		.015
	.021		.016
	.022		.016
	.024		.017
	.025		.017
	.026		.018
	.026		.018
	.028		.020
	.028		.022
			.024
			.025
			.044

1 ***Individual kidney samples were homogenized in PBS-Tween 20 buffer at a 1:3 weight/volume dilution.***

Appendix Table A-21. Date and number of spawned adults sampled for culturable viruses from Carson spring chinook salmon spawned in 1994 at Lyons Ferry Hatchery for Umatilla Hatchery 94 brood year production. Culturable viruses were sampled for as individual ovarian fluids (OF) from females, individual milts from males (M) and four-female pyloric caeca/kidney/spleen (PKS) pools.

Date sampled	OF	M	PKS
08-24-94	14	14	4
08-3 l-94	46	46	12
09-07-94	69	68	
W-14-94	17	17	

Appendix Table A-22. Date and number of Carson spring chinook salmon adult females sampled for erythrocytic inclusion body syndrome (EIBS) during spawning at Lyons Ferry Hatchery in 1994 for Umatilla Hatchery 94 brood year production.

Date sampled	Number of fish sampled
08-24-94	14
08-31-94	20
09-07-94	20
09-14-94	17

Appendix Table A-23. ELISA readings (OD_{405}) for ***Renibacterium salmoninarum*** of 32 kidney samples[1] from Carson spring chinook salmon females spawned on 09-06-95 at Lyons Ferry Hatchery for Umatilla Hatchery 95 brood year production.

ELISA OD_{405}	
.017	.051
.021	.054
.022	.054
.024	.054
.026	.055
.030	.056
.031	.058
.031	.063
.033	.065
.036	.067
.041	.071
.042	.071
.042	.072
.044	.079
.045	.085
.049	1.584

1 ***Individual kidney samples were homogenized in PBS-Tween 20 buffer at a 1:3 weight/volume dilution.***

Appendix Table A-24. Date and number of spawned adults sampled for culturable viruses from Carson spring chinook salmon spawned in 1995 at Lyons Ferry Hatchery for Umatilla Hatchery 95 brood year production. Culturable viruses were sampled for as individual ovarian fluids (OF) from females, individual milts from males (M) and four-female pyloric caeca/kidney/spleen (PKS) pools.

Date sampled	OF	M	PKS
09-06-95	32	32	8

Appendix Table A-25. Date and number of Carson spring chinook salmon adult females sampled for erythrocytic inclusion body syndrome (EIBS) during spawning at Lyons Ferry in 1995 for Umatilla Hatchery 95 brood year production.

Date sampled	Number of fish sampled
09-06-95	32

Appendix Table A-26. ELISA readings (OD_{405}) for *Renibacterium salmoninarum* of 24 kidney samples from Carson spring chinook salmon females spawned at Wallowa Hatchery in 1994 for Umatilla Hatchery 94 brood year production.

Date sampled	ELISA OD405	Date sampled	ELISA OD_{405}
08-23-94	.019	*08-30-94*	.015
	.030		.022
	.030		.025
	.034		.026
	.034		.029
	.045		.029
	.049		.032
	.055		.057
	.123		.082
	.340		.547
	.364		
	.721	09-06-95	.024
			1.031

[1] ***Individual kidney samples were homogenized in PBS-Tween 20 buffer at a 1:3 weight/volume dilution.***

Appendix Table A-27. Proportions and prevalences of infectious hematopoietic necrosis virus (IHNV) detected in individual ovarian fluid (OF), milt (M) and five-female pyloric caeca/kidney/spleen (PKS) samples collected from Carson spring chinook salmon spawned in 1994 at Wallowa Hatchery for Umatilla Hatchery 94 brood year production.

Date sampled	Proportion and prevalence (%) of IHNV		
	OF	M	PKS
08-23-94	1112 (8.3%)	3/12 (25%)	0/3 (0%)
08-30-94	3/10 (30%)	0/10 (0%)	1/4 (25%)
09-06-94	o i 2 (0 %)	0/2 (0%)	O/l (0%)
Total	4/24 (16.7%)	3/24 (12.5%)	1/8 (12.5%)

Appendix Table A-28. Date and number of Carson spring chinook salmon adult females sampled for erythrocytic inclusion body syndrome (EIBS) during spawning at Wallowa Hatchery in 1994 for Umatilla Hatchery 94 brood year production.

Date sampled	Number of fish sampled
08-23-94	12
08-30-94	10
09-06-94	2

Appendix Table A-29[1]. Distribution of ELISA (OD_{405}) values, *by* OD range, for ***Renibacterium salmoninarum*** of 908 kidney samples[2] from Bonneville fall chinook salmon by spawning date in 1994 for Bonneville Hatchery 94 brood year production. The total number of fish and the percent (%) of the 908 fish sampled within each range are at the bottom of each OD range column.

Spawning Date	Number of fish per ELISA OD_{405} Range						
	.000-.099	.100-.199	.200-.399	.400-.599	.600-.799	.800-.999	>1.000
11-01-94	108	1	3	2	1	0	0
11-08-94	255	10	2	1	2	1	1
11-15-94	124	1	1	2	1	1	2
11-23-94	102	8	3	4	2	1	7
11-28-94	118	4	1	1	1	1	9
12-09-94	85	12	4	2	4	1	19
Total (%)	792 (87.22)	36 (3.97)	14 (1.54)	12 (1.32)	11 (1.21)	5 (.55)	38 (4.19)

1 ***These analyses were done and data provided by rhe ODFW Corvallis Fish Pathology** Laboratory **funded under a Bonneville Power Administration Bacterial Kidney Disease contract.***

2 ***Individual kidney samples were homogenized in PBS-Tween 20 buffer at a 1:3 weight/volume dilution.***

Appendix Table A-30[1]. Proportions and prevalences of infectious hematopoietic necrosis virus (IHNV) detected in ovarian fluid (OF), pyloric caeca/kidney/spleen (PKS)[2] and gill samples collected from Bonneville fall chinook salmon spawned in 1994 for Bonneville Hatchery 94 brood year production.

Date sampled	Proportion and prevalence (%) of IHNV OF	PKS	Gill
11-01-94	0/20 (0%)[3]	0/12 (0%)	0/12 (0%)[5]
11-08-94	0/20 (0%)[3]	ND	ND
11-15-94	0/16 (0%)[3]	ND	ND
11-23-94	14/16 (87.5%)[3]	ND	ND
11-28-94	14/16 (87.5%)[3]	ND	ND
12-09-94	27/28 (96.4%)[4]	ND	5/16 (31.3%)[6]
Totals	55/116 (47.7%)	0/12 (0%)	5/28 (17.9%)

1 *These analyses were done and data provided by the ODFW Corvallis Fish Pathology Laboratory.*
2 *PKS samples were from five-female pooled samples.*
3 *Ovarian fluids were three-female pooled samples.*
4 *Ovarian samples were 16 three-female pools and 12 individual samples.*
5 *Gill samples were from jive-female pooled samples.*
6 *Gill samples were from three-female pools*

Appendix Table A-3 1. Proportions and prevalences of erythrocytic inclusion body syndrome (EIBS) detected in blood smears collected from Bonneville fall chinook salmon spawned in 1994 for Bonneville Hatchery 94 brood year production. [1]

Date sampled	Proportion and prevalence (%) of EIBS	
	Male	Female
11-01-94	0/20 (0%)	0/20 (0%)
11-08-94	1/20 (5.0%)	0/20 (0%)
11-15-94	0/20 (0%)	0/20 (0%)
11-23-94	3/20 (0%)	0/20 (0%)
11-28-94	2/20 (10.0%)	0/20 (0%)
12-09-94	3/20 (15%)	0/20 (0%)
Totals	9/120 (7.5 %)	0/120 (0%)

1 These analyses were done and data provided by the ODFW Clackmas Fish Pathology Laboratory.